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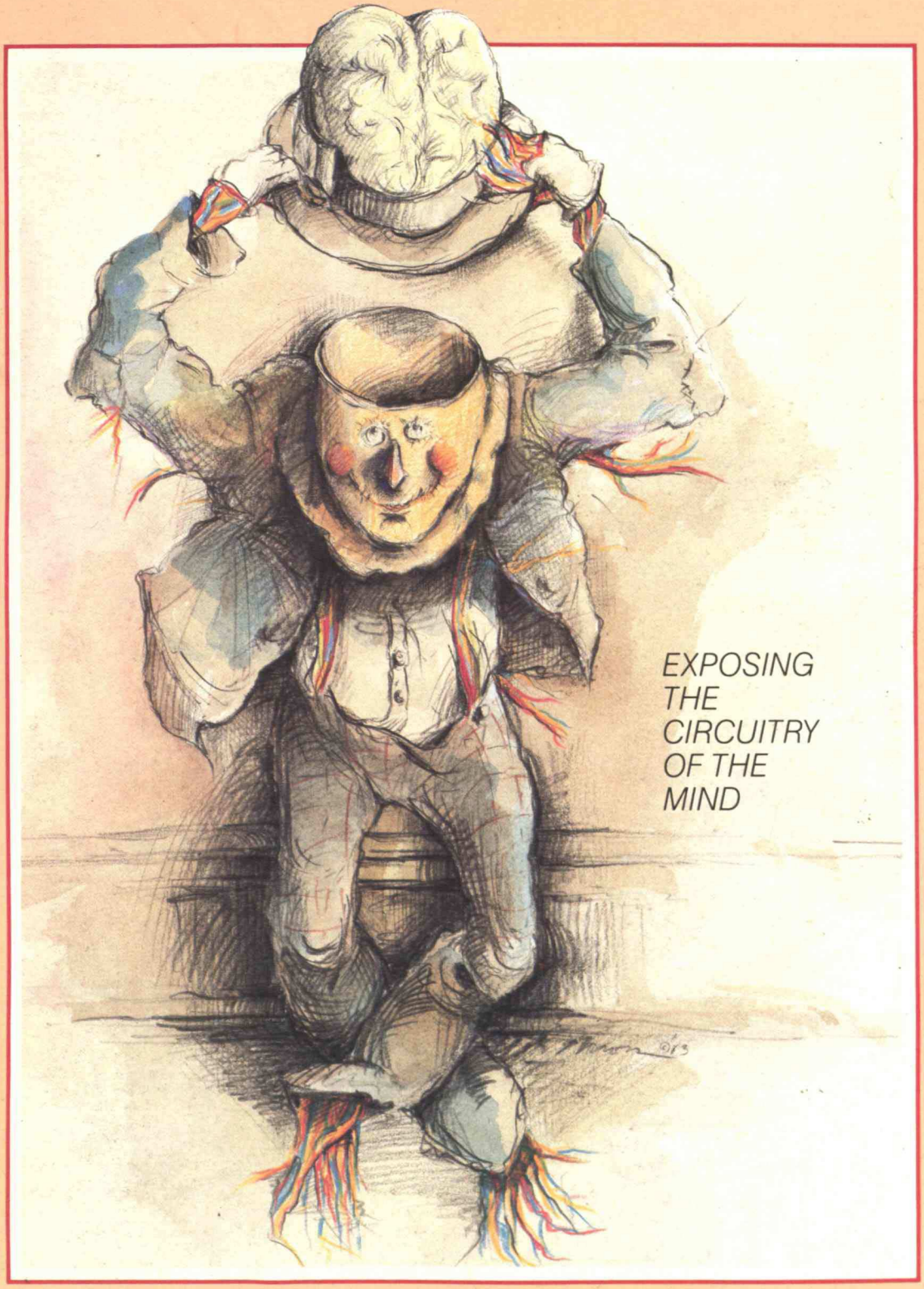
Technology Review

EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY NOVEMBER/DECEMBER 1983 $3.00



EXPOSING THE CIRCUITRY OF THE MIND

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The new 190 E 2.3 Sedan: a $24,000 four-door wedge that weighs 2,655 lbs., has an aerodynamic drag coefficient of 0.35,*

Introducing the new 190 Class: the standards of Mercedes-Benz in an automobile like none before.

MERCEDES-BENZ HAS computed a bold new equation of space and mass and energy. From it has emerged a new automotive category: the 190 Class of gasoline- and diesel-powered sedans, priced in the $24,000 range.

The 190 Class extends the unique Mercedes-Benz synthesis of high technology, obsessive quality and sheer driving exhilaration into territory ripe for such leadership.

It breaks through previous limits. Sets new performance parameters. Achieves a level of balanced excellence achieved by no other automobiles of similar size and weight.

In sum, the 190 Class is more than a new model from Mercedes-Benz. It is a new example for the automotive world of the eighties.

BREAKTHROUGH SUSPENSION

The engineers spent five years, and investigated 70 variations of eight principal systems, en route to the *multilink* independent rear suspension that is the car's crowning technological advance.

It helps make this four-door Mercedes-Benz a blend of agility and stability that, *Road & Track* predicts, "...will challenge some of the finest sports sedans in the world on just about any road you choose."

Each rear wheel is independently located by five precisely aligned links, which swing through interacting arcs during wheel movement and function as a unit to maintain the rear wheels in an attitude parallel to the road surface. Translation: the 190 Class tracks as if on rails. Roadholding poise and adhesion are almost uncanny.

The 190 Class is the trimmest and lightest Mercedes-Benz sedan of modern times. Multilink suspension makes it the best-handling Mercedes-Benz sedan in history.

The new 190E 2.3 Sedan seeks to redefine four-cylinder gasoline performance–upward.

Its fuel-injected 2.3-liter engine lifts the 190E to a 115-mph-plus test track maximum, yet generates high torque at low engine speeds for responsive snap in every driving range–even in fourth gear at 55 mph. It is an engine superbly matched with an automobile that almost begs for spirited driving. Smoothness was not forgotten; it carries *eight* crankshaft counterweights, plus a vibration damper.

NEW KIND OF DIESEL

The new 190D 2.2 Sedan equally revises ideas about four-cylinder diesel performance. It advances Mercedes-Benz diesel engine technology to new levels of sophistication and efficiency. (In cold weather, it even preheats its own fuel.) And in perhaps the most imaginative diesel noise-abatement step of them all, it sits *encapsulated* within the engine compartment, surrounded by sound-deadening panels.

Introduced simultaneously with these new engines is a new five-speed manual gearbox, with synchromesh even on reverse and fifth functioning as an overdrive gear for easier highway cruising. You can order this manual or a four-speed automatic version of both the 190E and 190D.

The 190 Class achieves what few production automobiles and almost no four-door sedans have ever achieved: an aerodynamic drag coefficient of 0.35.

Wind roar is dulled to almost nothing. So obsessed with aero-

*Approximate suggested advertised delivered price at port of entry. †See your authorized dealer for complete warranty information.

can reach 115-mph-plus on the test track, and is built to the uncompromising standards of Mercedes-Benz.

dynamic efficiency were its designers that they even faired a wind deflector onto the undersides of the main rear suspension arms, to help manage the airflow streaming beneath the car.

"WHICH MERCEDES IS THIS?"

Into this 14½-foot aerodynamic wedge has been designed civilized passenger space, accessible via four wide-opening doors and backed by a deep, rectangular 11.7-cubic-foot trunk.

"The most astounding thing happens when you take the driver's seat...you would be hard pressed to tell what Mercedes you are in," marvels one writer.

This no doubt derives in some measure from the sense of security and solidity imparted by every Mercedes-Benz. Another reason may be that its 41 inches of front legroom exactly matches that found in the largest Mercedes-Benz sedans built today.

The two supple front bucket-type seats are adjustable to almost infinite combinations of height, seatback rake, and fore-and-aft travel. The standards of Mercedes-Benz prevail in comfort as they do in engineering: the 190 Class is fully equipped and consummately well crafted, down to its hand-worked wood interior trim.

The 190 Class carries forward intact the Mercedes-Benz safety philosophy and Mercedes-Benz safety technology. Such critical features as collapsible front and rear body sections, meant to absorb kinetic energy in a major impact, are designed in. One nontechnological innovation is worth note: the 190 Class comes with a remarkable 48-month-or-50,000-mile limited warranty as standard.†

SACRED STANDARDS

The 190 Class, in the form of the new 190E 2.3 and 190D 2.2 Sedans, opens an exciting new chapter in automotive history. It meanwhile continues one of the oldest traditions in automotive history. For what it achieves has been achieved without deviating by one single millimeter from the sacred standards that make a Mercedes-Benz a Mercedes-Benz.

Engineered like no other car in the world

NOV/DEC 1983 VOL. 86 NO. 6

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TechnologyReview

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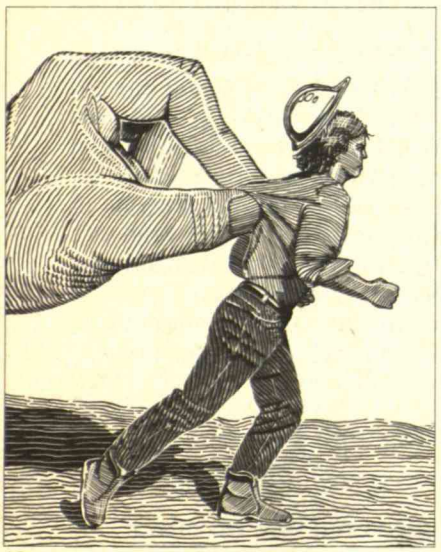

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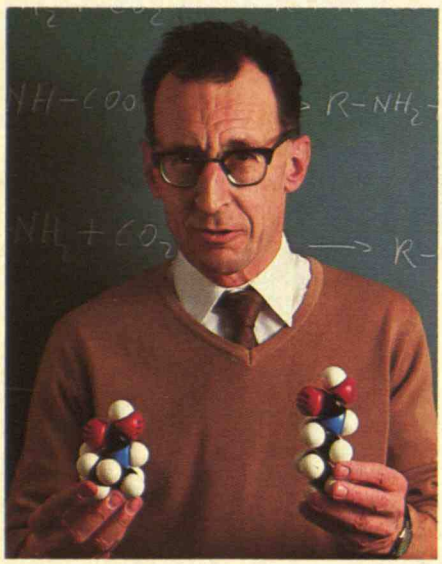
How Exxon developed can double the productivity

Guido Sartori's work on hindered amines may impact an entire industry.



Removing impurities such as carbon dioxide and hydrogen sulfide from natural, refinery, and synthesis gases is an expensive, energy-consuming process.

But at Exxon Research and Engineering Company a new chemistry discovery, and cross functional teamwork, have led to the development of a new technology—one that significantly decreases the cost and increases the capacity of commercial gas treating processes.

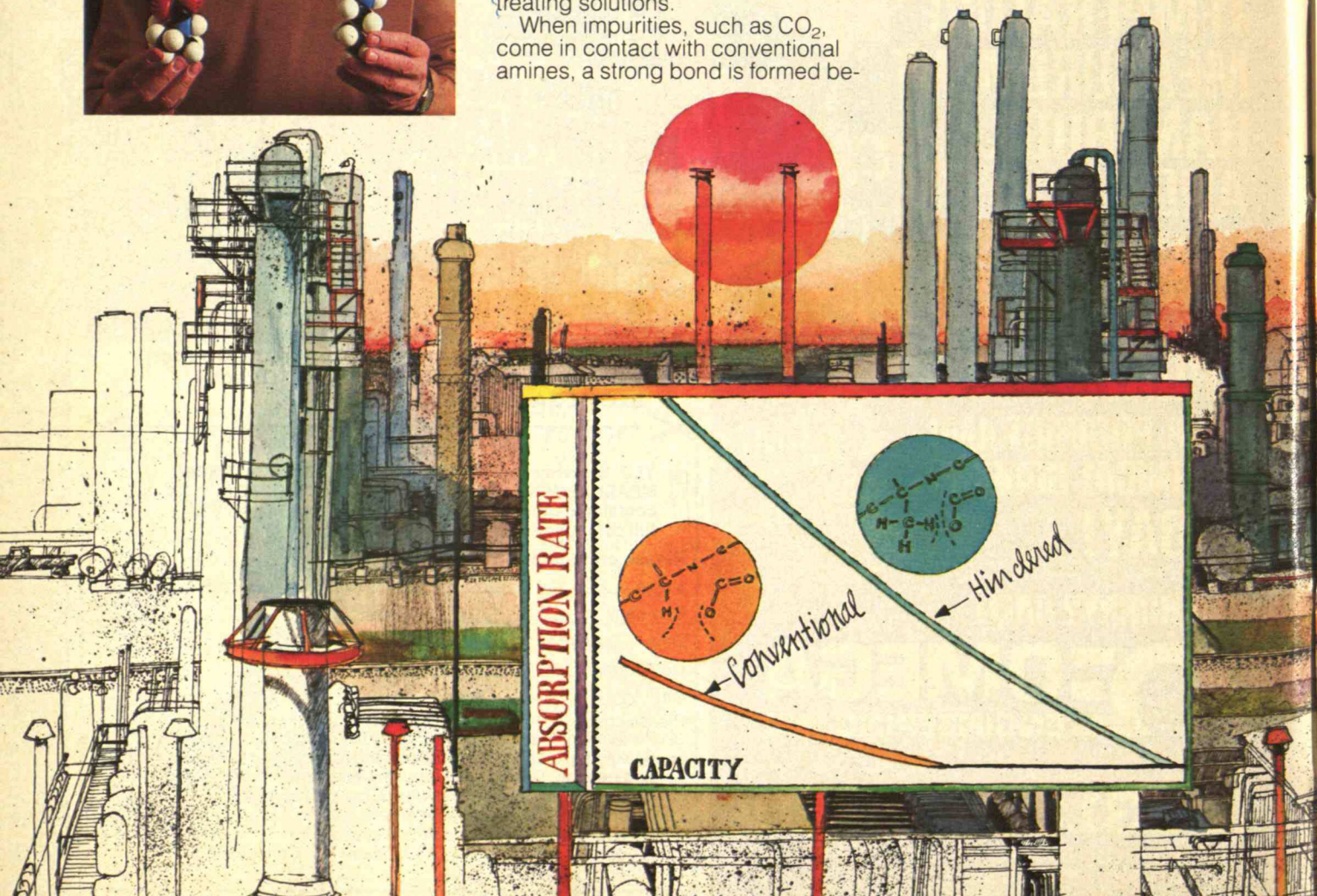
Research Led to a Discovery

Guido Sartori, a chemist in Exxon Research and Engineering Company, had been conducting research on amines—organic nitrogen-containing molecules—to increase both the absorption rate and capacity of gas treating solutions.

When impurities, such as CO_2, come in contact with conventional amines, a strong bond is formed between the CO_2 and the nitrogen atom of the amine. This strong bond ties up a disproportionate amount of useful amine. Sartori theorized that both the absorption rate and capacity of the amine would be improved if the bond at the nitrogen site could be weakened. Continuing research revealed the advantages of a whole new class of amines, which he called hindered amines.

Observing Molecular Behavior

Sartori and others began a comprehensive evaluation of the discovery, utilizing the company's advanced analytical capabilities. To understand the behavior of hindered amines, and to monitor reactions, Sartori employed the results of carbon-13 nuclear magnetic resonance spectroscopy, a



new molecules that of gas treating plants.

state-of-the-art technique not previously used for this purpose.

Further research confirmed the hindered amines' capability to substantially increase the rate and capacity of carbon dioxide absorption through the formation of low stability bonds. Low stability was achieved by placing a bulky substituent next to the nitrogen sites, thereby hindering bond formation with CO_2. Building on this new understanding, he synthesized new molecules to meet the performance requirements for specific applications.

Integrated Innovation

Other Exxon organizations joined the effort to develop improved gas treating technology. After the hindered amines had been evaluated at the laboratory bench, process development was required on a larger scale. A major pilot plant program confirmed, broadened and extended the bench scale results and helped to define the capabilities of the hindered amines. An engineering program was an integral part of the research and development required to convert these laboratory discoveries into commercially feasible technologies. Capacity increases of 50% have been achieved commercially using this technology with no added facilities.

Through integrated innovation–the combined efforts of the company's basic research, process development, and engineering staffs–hindered amine technologies advanced from scientific discovery through commercial use in less than three years. Further research has enabled ER&E to identify or synthesize other practical hindered amines.

Exxon Research and Engineering Company

Research on hindered amines is just one example of the numerous programs underway at ER&E. A wholly owned subsidiary of Exxon Corporation, ER&E employs some 2,000 scientists and engineers working on petroleum products and processing, synthetic fuels, pioneering science and the engineering required to develop and apply new technology in the manufacture of fuels and other products. For more information on Exxon's hindered amine technology or ER&E, write Dr. E. E. David, President, Exxon Research and Engineering Company, Room 707, P.O. Box 101, Florham Park, New Jersey 07932.

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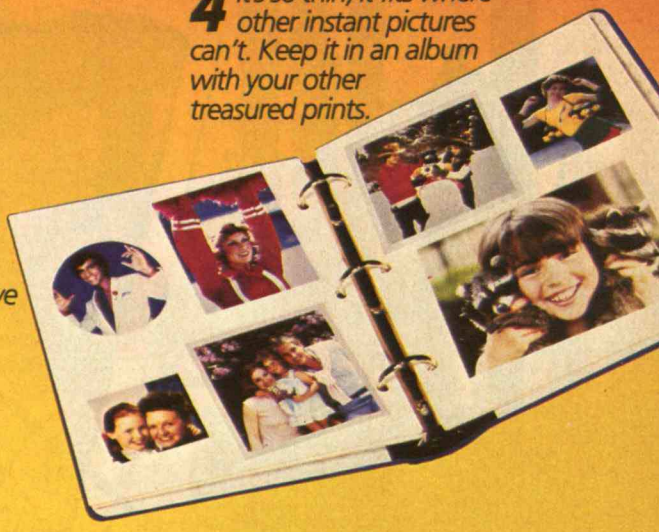

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nal Green in the East of London (*"The Amazing Crystal Palace" by Henry Petroski, July, page 18*). The structure now houses both the Children's Museum—a branch of the prestigious Victoria and Albert Museum, which is devoted to recording children's earlier years—and a collection of books on the history of the silk industry, a service appropriate to this area of London. More of Paxton's work in the style of the Crystal Palace is at Kew Gardens in the main observatory.
Jeffery Lewins
Cambridge, England

Too Much of a Good Thing?

Highest commendations to the *Review* and the author of "Overdosing on Medical Technology" (*August/September, page 12*). David Hellerstein's most timely presentation is accurate, lucid, and cogent.
Frederick W. Nordsiek
Chapel Hill, N.C.

"Overdosing on Medical Technology" is an eloquent and accurate description of the agony of prolonging terminal illness. The report of the President's Commission on Medical Ethics, issued last spring, also stresses the need for change in doctors' training and attitudes, and for increased attention to patients' wishes.

Individuals can best protect themselves from overtreatment by giving a written statement of their wishes to their family, doctor, hospital, or counsel. Likewise, if someone person wishes aggressive treatment as long as there is a spark of life, that should also be put in writing.
L.R. Steffens
Darien, Conn.

Sales and Legends

The fact that there is intense competition within Japanese industry does not prove "The Myth of Japan Inc." (*Toshimasa Tsuruta, July, page 42*). The term "Japan Inc." does not imply actual government control of industry, such as in a planned economy, but rather the formulation of industrial policy by consensus among leaders in business and government. This process is somewhat akin to England's "old-boy system" but occurs on a much wider and more formalized basis. As members of the same committees, participants from Japanese government, industry, and associations know one another well. As alumni of the same universities, they have had the opportunity to establish mutual understanding and confidence over decades and are bound by a common set of loyalties and values to a degree unknown in the West.

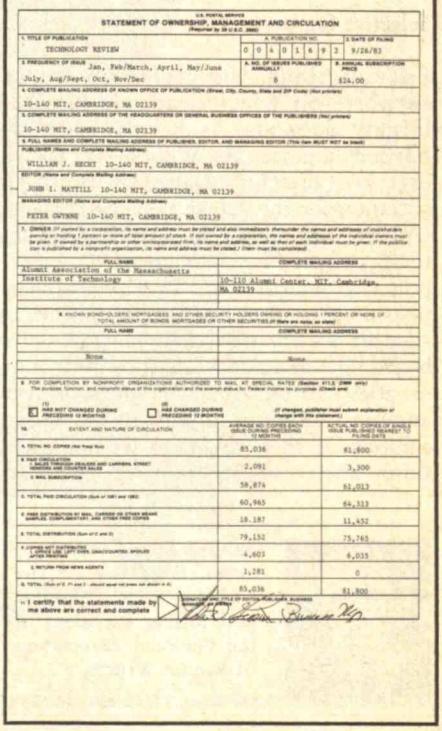
Even so, consensus between the Ministry of International Trade and Industry (MITI) and business is not always achieved. For example, Honda expanded from its traditional field of motorcycles into passenger cars against the express wishes of MITI. On the other hand, Fujitsu did delay its entry into the U.S. market by several years upon MITI's recommendation.

The government influences the domestic market by imposing import controls. These guarantee domestic suppliers a home base of 120 million largely affluent consumers. This factor alone—and there are many more—shows that Japan Inc. is not the ephemeral creature Professor Tsuruta would have us believe.
Christoph-Friedrich von Braun
Tokyo, Japan

Science for the Public

I strongly disagree with the authors' disinterest in upgrading math and science education in "The Low-Skill Future of High Tech" *(by Henry M. Levin and Russell W. Rumberger, August/September, page 18).* Focusing on employment narrows their judgment of the merits of a concerted effort to improve training in these areas. In our society, a technically ignorant public is being forced to function in a highly technical environment. This deficiency should be addressed by providing citizens with a basic understanding of mathematical and scientific concepts.
Vincent P. Manno
Framingham, Mass.

The authors respond:
We did not mean to imply that there was no reason for upgrading math and science education. Rather, we merely meant that the future demands of the workplace were unlikely to require many workers with high-level math and science training. We agree that upgrading math and science education will make citizens more knowledgeable about the technical forces that will increasingly shape their lives. Such a background will help them become more involved in making decisions that will shape that future.



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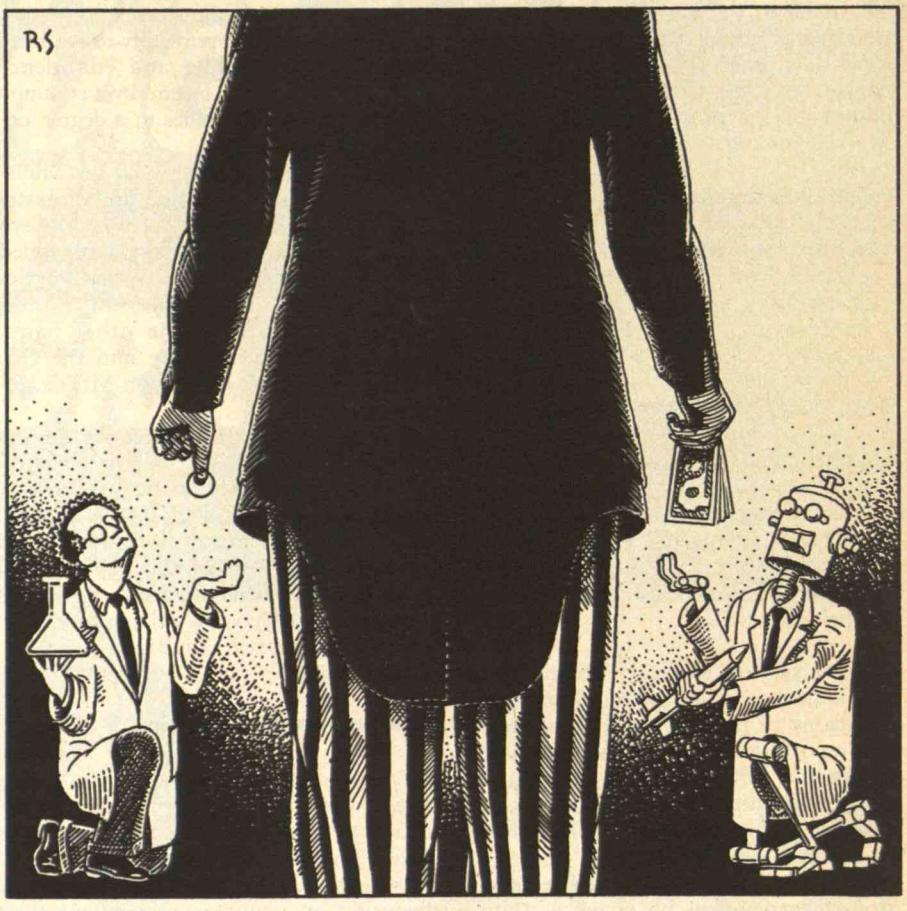
ROBERT C. COWEN

Targeting an Expanded Research Budget



THERE'S a pot of new money at the end of the rainbow that now brightens the horizon of the U.S. research community. Analysts for the National Science Foundation estimate that R&D spending in 1983 should run to $86.5 billion overall. For 1984, they project it should reach $97 billion. That would be "real" growth of about 7 percent, if 1983 inflation has been held to under 5 percent.

Meanwhile, presidential science advisor George A. Keyworth II has been preaching a new R&D gospel. He emphasizes that contrary to what people may once have thought, the "mobilization of scientific research and industrial high technology to spearhead economic progress" is an "overwhelming" national priority for the Reagan administration. This is reflected in a projected 12.3 percent rise in federal R&D spending—up from an estimated $39.6 billion this year to $44.5 billion for 1984.

What a change all this is from the gloomy outlook that prevailed a couple of years ago! At that time, administration funding cuts had research leaders proclaiming a "crisis" for U.S. science. Now the administration gives science top priority. Why, then, is there so little cheering from the research community, especially from the academic side?

Selective Support

For one thing, the beefed-up federal support—on which academic research largely depends—is hardly an even-handed largesse. As William D. Carey, executive director of the American Association for the Advancement of Science (AAAS), has noted, the gospel according to Keyworth "is a statement of science policy with teeth in it." Dr. Keyworth emphasizes that the administration means to support science selectively, not across the board. He insists that "science in the universities and the federal laboratories can and must be better attuned to the opportunities of the industrial world." Mr. Carey observes that "the government believes . . . research will have to produce a positive bottom line. And that is clearly a different signal than basic science is accustomed to hearing."

On top of this, the administration continues to try to tighten its control over nonsecret, nonmilitary scientific and engineering information. The controls have been promulgated through regulation of weapons trade and other exports and, lately, through the Federal Acquisition Regulations (FAR), which assert the government's proprietary right to data developed with federal funding. Stanford University has released a public protest against these regulations, saying that the FAR restrictions are so broad that they amount to "prior written censorship by government officials . . . [of] books, monographs, seminars, unpublished papers, graduate-student theses, and other informal means of scholarly exchanges." The government says it is trying to keep U.S. know-how at home. But the academic community is worried that secrecy would strangle their enterprise and "dull the very technological edge we seek to protect," to quote M.I.T. President Paul Gray.

Thus, while the administration's new emphasis on research and its more robust funding is welcome, its priorities make scientists and research administrators feel uneasy.

For his part, Dr. Keyworth says it's time for researchers to face what he considers a fundamental fact—federal support is an investment, not an entitlement. Science, he says, "is not on the list of public obligations . . . that have to be funded according to an egalitarian formula." The administration's increased funding, he explains, is "targeted to areas likely to have the greatest long-term impacts on new technologies," including mathematics, physics, engineering, plant biology, materials science, and the space sciences. He makes little mention of anthropology, economics, or social science, which presumably are still considered too "soft" to be funding targets.

ROBERT C. COWEN is science editor of the *Christian Science Monitor* and former president of the National Association of Science Writers.

ILLUSTRATION: ROB SAUNDERS

Dr. Keyworth also says the administration is targeting money "specifically to universities, where research involves training of people needed in our increasingly technology-dependent economy." That's nice. But what about universities as communities of scholars where individuals can gain an education with the breadth and depth needed to be a citizen in the modern world? Scientists and technologists need the perspective of the humanities. And liberal-arts majors need an informed perspective on science and engineering. National Academy of Sciences President Frank Press has observed, "A lot of our liberal-arts graduates are technologically illiterate. They're going to become leaders—lawyers, government officials—but they're really ignorant of the basic new directions of society that technology is thrusting us into."

A Balancing Act

Targeted research support carries the danger that some fields that will be vital tomorrow may be neglected today. Targeted educational support risks creating a cadre of narrow research specialists within a society managed by those who can't understand what the researchers are doing. Somehow, a policy that emphasizes getting the biggest economic bang for the support buck seems misguided as far as basic science and education are concerned. The contribution these make to economic strength is that of a general foundation for the national culture. Trying to build up parts of that foundation while neglecting the rest only weakens the whole.

The administration says it is aware of this danger. Dr. Keyworth explains that the government wants to find the most promising growth points over the entire landscape of science and encourage them. He is urging scientists themselves to help establish such priorities. Planetary scientists have done this and now look forward to a new affordable exploration program. This must be done in all fields, Dr. Keyworth says. There is wisdom in this: if research funds are scarce, scientists are better off helping to make the hard choices than to have the choices imposed upon them. Nevertheless, many scientists feel that targeted research could easily become a policy of selective neglect.

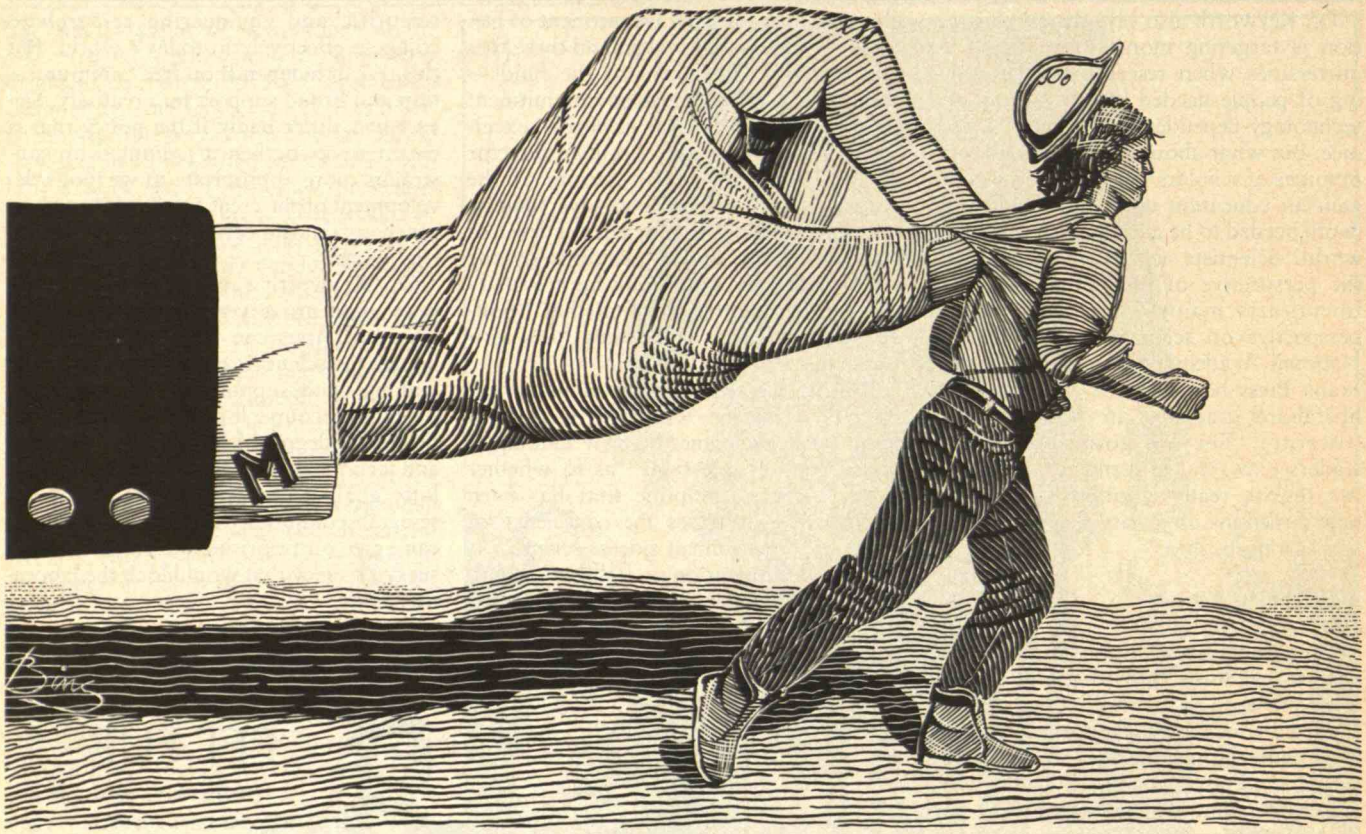
This suspicion stems from the fact that 67 percent of the federal R&D money is channeled through the Department of Defense. Add the space budget and these two areas absorb 70 percent of the funds—seemingly a rather lopsided commitment to maintaining general scientific excellence. Robert L. Park, executive director of the Office of Public Affairs of the American Physical Society, says funding for university physical science is level or even declining. And an analysis by the AAAS makes the same point for university research generally, warning that "non-defense R&D may be heading for a serious squeeze."

William Carey accurately sums up scientists' concern when he says that although he welcomes the new funding, it raises "deeper questions" as to whether "the political discipline that has been applied . . . addresses the conscience of science . . . the human side of science."

The administration is right in its perception that the United States needs strong scientific and engineering research to compete effectively in today's world. But this research depends on free communication and broad support for creativity. Science can suffer badly if the policy that is meant to strengthen it is limited by constraints more appropriate to weapons development or the creation of products "attuned to the opportunities of the industrial world."

Dr. Keyworth says that "the coming year could prove very important for the future of American basic research." He invites the scientific community to join in making—and supporting—decisions that "may set a course for a healthy and beneficial new degree of integration of science and technology in American life." That's a lofty goal. It can only be realized if the research community and the government can agree on priorities and resolve the issues of secrecy that would lock the laboratory door. □

The Changing American Workplace



1. Democracy in the Workplace: An Elusive Goal

By KENNETH O. ALEXANDER

Few topics have received more recent attention than the question of how we might reorganize work environments for more productive results. But while the literature has been galloping out of control, the pace of actual change is better described as a leisurely stroll. This is somewhat exasperating to the proponents of change, who typically recommend greater worker participation and shared decision making.

Such proponents, myself included, believe that a move away from the traditional hierarchy of American management will bring benefits both tangible and intangible. The tangible lies in the improved productivity that can come from eliciting ideas from all workers, instead of from a few managers with limited information. The intangible lies in increased job satisfaction. Volumes have been written about the sense of self-fulfillment experienced by individuals who are treated as valued partners instead of inferior workers. Participatory work organizations would also reduce the contradiction between our national philosophy of respect for the individual and the inferior status of most American workers.

In the United States, some companies have made substantial efforts to involve workers in important decisions. Since the late 1940s, dozens of companies have employed the Scanlon plan, using worker-management meetings to enhance productivity and then sharing the resulting cost savings. Conferences have also been held to acquaint managers with the potential gains and problems of involving workers in decision making. National and regional organizations, such as the American Center for the Quality of Working Life in Washington, D.C., have been established to study and promote greater worker participation. But real change has been relatively slow. To better understand why, we must look at the major protagonists: the people who could be sources of change in the workplace.

Sharing Managerial Power

Power in the United States has traditionally resided with the ownership of property, so theoretically change in the workplace should start with the owner. While some owner-managers of small businesses share decision making with employees, the bulk of the American work force is corporate, with ownership residing with stockholders. But stockholders have been divorced from control of the enterprise for many years. Stockholder groups may occasionally use their position to exert pressure on social issues. Or they may become involved in struggles relating to mergers or acquisitions. But by and large, power in American companies and control over daily activities in the workplace have been ceded to professional

ILLUSTRATIONS: CHRISTOPHER BING

Rather than rewarding the work ethic, managers convey the message that commitment is neither necessary nor desirable.

managers.

Obviously then, managers could initiate change. In fact, managers have been the primary source of change in the workplace so far. But, for a number of reasons, managers who undertake ambitious programs to improve worker participation probably will continue to be the exception. To begin with, it is difficult for anyone to give away status and power. For most managers, it is easier and more self-protective to operate as the traditional superior. Information can be controlled, options kept confidential, criticism muted and channeled.

There are other problems in implementing change as well. Sometimes not all levels of management are convinced that change is desirable, and their resistance could easily sour any movement toward a more participatory work organization. Sometimes, managerial insensitivity to employee concerns inhibits change. Last year, for instance, General Motors announced that its contract with workers constituted "a new alliance with labor." GM Chairman Roger Smith declared, "It moves us in a new direction—away from confrontation and toward cooperation . . . It seeks to directly involve the union and its members in the effort to make GM more competitive." But on the day the new contract, which included union concessions to reduce costs, was signed, GM announced an enhanced executive bonus plan. The bonus plan was quickly renounced after workers protested, but the sense of cooperation and trust that is vital to a successful participatory organization was damaged. As one local union vice-president commented, "Our people thought management was lining its own pockets with our concessions."

There is also the question of how far participatory decision making should go. Worker suggestions on how to improve familiar tasks can add to efficiency. But will workers, once given a taste of decision making, seek to affect higher-level decisions on product design and plant layout or location? On one hand, rigidly restricting the sphere of participation will compromise it. On the other hand, expanding it will mean encroachment into areas long considered exclusive realms of management. It is no simple task to move an organization from authoritarianism to participation, and many managers probably will decline the challenge.

(Continued on next page)

2. Putting the Work Ethic to Work

BY DANIEL YANKELOVICH AND JOHN IMMERWAHR

TODAY the United States is in the grip of a second industrial revolution. While the first, stretching the 1870s to the 1970s, shifted the American economy away from agriculture to industry, the new revolution is shifting the economy away from traditional "smokestack" industries to those based on information, services, and new technologies. With this second revolution have come major changes in the American workplace. One of the most important—and least noticed—changes is a dramatic growth in the amount of control that individual jobholders have over their work.

Three factors are primarily responsible for this growth in discretion. To begin with, there has been a major shift in the type of jobs Americans hold—away from low-discretion blue-collar and manufacturing jobs toward high-discretion white-collar and service jobs. Public-school teachers, to choose one example, now outnumber all of the production workers in the chemical, oil, rubber, plastic, paper, and steel industries combined. Our research, based on interviews with a national sample of 845 jobholders, shows that white-collar jobs typically carry higher levels of discretion than blue-collar jobs. Close to half (49 percent) of all white-collar jobholders, for example, say they have a great deal of freedom in how to perform their jobs; only a third of blue-collar workers (33 percent) describe their jobs the same way.

More Freedom on the Job

The advent of new technologies has also had the effect of giving jobholders more discretion over their output, according to our survey. Of the close to half (44 percent) of American jobholders who say that they have experienced significant technological changes in their jobs over the last five years, more than 74 percent say the changes have made their jobs more interesting. More than half (55 percent) say that technological changes have given them greater independence.

There has also been a change in the composition and values of the workforce. Education levels have risen sharply. Between 1959 and 1977, the percentage of high-school graduates in the workforce rose from 32 percent to 42 percent, and the number of college graduates nearly doubled, jumping from 10 percent to 18 percent. Younger jobholders, who grew up in a period of tremendous affluence, are also bringing new values to the workplace. In the past, many workers were willing to sacrifice a great deal of their autonomy in exchange for a good income and an increasing standard of living for themselves and their families. A report published by the Work in America Institute, a nonprofit research organization in Scarsdale, N.Y., estimates that "ten years ago, 70 percent of industrial workers were willing to accept managerial authority with minor reservations. Today, the reverse finding has emerged: younger, more educated workers resent authoritarianism." These jobholders have demanded, and to some extent received, greater autonomy in the workplace.

Workers: Not Giving Their All

The growth of discretion in the workplace reduces the control that employers exer-

(Continued on page 16)

Wary of management's true motives, many unions are lukewarm about adopting the new role of partner.

Unions Leery of Change

If managers will not share power voluntarily, they may be forced to do so. Indeed, unions arose in response to authoritarianism in the workplace—the union functions as an adversarial offset to management authority. Unions could be viewed as a vehicle for gaining greater worker input into production decisions. However, unions generally have responded to management initiatives where and when they occur rather than serving as prime movers toward change.

Some major unions, including the steelworkers, autoworkers, and communication workers, have been cooperating with management to establish quality circles (where workers exchange ideas with managers on ways to improve productivity and product quality) as well as other forms of worker participation. The general posture of unions, however, is one of caution mixed with suspicion. Union leaders are concerned that participation may draw workers closer to management and thereby weaken unionism. As William Roehl, assistant director of organizing for the AFL-CIO, said, "A number of well-meaning people believe that quality circles can lead to improvements in the workplace. But what they don't know is that they can also be part of a company's union-busting strategy."

This skepticism is reinforced by the way some American employers have responded to the recent recession. While some employers are seeking to draw workers into a cooperative arrangement to improve productivity, others are mounting an intensified campaign to eliminate or prevent unionism. Wary of management's true motives, many unions are lukewarm about adopting the new role of partner in the production process. Speaking to business leaders, Glenn Watts, president of the Communication Workers of America, has said, "You can't ask unions to walk hand in hand into the unknown land of worker participation while going full speed ahead with union-busting anti-labor programs. There has to be a greater acceptance of unions in this country. I want very much to cooperate in consensus building and problem solving, but management can't expect cooperation when the hand it puts around my shoulder has a knife in it."

Even if so inclined, unions could not force participatory workplaces to be established. In the final analysis, the genuine willingness of management is the key to successful transition. The essential spirit of cooperation cannot be brought about by formal mandate and contractual obligation. Such an attempt probably would degenerate into an energy-sapping legal struggle that would result in few gains.

Workers Will Not Lead

With their union representatives reluctant to lead the thrust for participatory decision making, the workers themselves cannot serve as protagonists of change. Once outside the union fold, workers are powerless and unorganized. Furthermore, there is little evidence that unions misread their constituencies when they fail to place workplace reorganization high on their list of priorities. By and large, workers are not visionaries who contemplate sweeping alternatives. Most learn to adjust and adapt to authoritarianism in the workplace and compensate with nonwork activities. The usual finding of greater satisfaction among older workers supports this conclusion: it is they who have learned to adjust.

In addition, higher unemployment in recessionary times tends to smother worker concern over participation—getting and keeping a job takes precedence. In Europe and Scandinavia, the reluctance of young workers to accept jobs contributed significantly to general concern over workplace organization. But such strong political statements grew out of an environment of "overfull" employment with the importation of foreign "guest" workers and the consequent social problems.

Some observers have expected the technically elite among the workforce to lead the way toward more participatory systems. The scientist, engineer, and technician play a key role in production, and participatory systems that draw out the best from these professionals would be of special importance in improving productivity. Unfortunately, success for many professionals, especially engineers, is equated with becoming a manager.

Consequently, few professionals will, on their own, push for change in the workplace. Nor are professional associations a base from which change can be launched. Few associations have expressed real concern over the issue of workplace reorganization, and some have been coopted by management to a significant degree. Furthermore, few professionals have been unionized in recent decades. Involvement in unions is often regarded as "unprofessional," and with both professional and managerial opposition, it is unlikely to grow. For many technical professionals, the acceptance of unionism becomes almost a denial of their special status, which rests solely on expertise.

If the major protagonists in industry will not lead the movement toward change, there is still the possibility of change through political action and government mandate. This certainly has been part of the process of change in other countries. Workplace organization has been a significant political issue in Europe, Britain, and Scandinavia. However, the United States does not have an equivalent history of socialist influence, and its citizens seem more reluctant to compromise the traditional powers of management under capitalism. Unions in the United States are also much less ideological and political than their foreign counterparts.

None of the groups discussed thus far appears likely to make shared decision making a political issue. With no constituency, the issue will remain largely ignored in American politics. And even if this were not so, the possibility that political action will result in genuine change in the workplace is remote. Political debate on that issue could easily degenerate into ideological name calling. Any challenge to managerial authority, for instance, would be opposed as anticapitalist or even anti-American. Any government mandate would focus on form and not substance and could not, of itself, produce the spirit of cooperation and sharing that is the essence of participation.

Foreign Competition Is Key

Despite these inhibiting forces, there is evidence of a gradual movement away from authoritarianism and toward participation in the American workplace. We are beginning to see a change in the conventional wisdom, in the myths of management, if you like. The top managers at many companies, including Fortune 500 firms, are realizing there are gains to be made from worker participation. Workers are far more educated than they used to be and are becoming increasingly interested

in participating in job decisions.

In a new three-year study of American workers, Daniel Yankelovich and John Immerwahr of the Public Agenda Foundation found that most workers have an inner need to do the best job possible, regardless of the pay. Yet most managers still cling to the old-fashioned notion of workers as unmotivated cogs in the wheel and fail to capitalize on this inherent work ethic. The result, Yankelovich and Immerwahr say, is a system that puts the United States at a competitive disadvantage in the world economy (*see "Putting the Work Ethic to Work," page 13*).

Ironically, what change has occurred in the United States is at least partly due to the success of foreign competitors who provide their workers with a greater sense of participation; the Japanese are a prime example. Therefore, the future pace of change in the workplace depends on the degree of foreign competition and the extent to which protectionist measures are used to insulate domestic companies from such competition.

If participatory work organizations bring enhanced productivity and job satisfaction, the employer who sticks with the old authoritarian ways will lose out to more flexible employers. Full employment would also abet change by providing workers with job alternatives if they continue to be left out of decision making at particular companies. Thus, once workplace reorganization gains a viable toehold in American industry, the speed with which it spreads will depend on market competition and unemployment levels.

Some people believe the change now taking place is due only to the recent recession—to the fact that managers, faced with falling profits, were willing to try anything. With the gradual return to economic prosperity, some believe managers will quickly revert to the old authoritarian ways. But I think participation in the workplace is here to stay. Foreign competition and the growing desire of American workers to participate in decision making will continue to keep the movement alive. In the long run, this country's economic prosperity is tied to workplace reorganization, if only because it may help restore our competitive edge. □

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A majority of workers describe themselves as having an inner need to do the best job they can, regardless of pay.

cise (particularly over the quality of output) and puts it into the hands of individual jobholders. However, commitment to the job has not kept pace with the growth of individual discretion. Many jobholders are holding back from their work, and quality has suffered accordingly. For instance, we found that fewer than one out of four jobholders (23 percent) say that they are currently working at their full potential. Nearly half of all jobholders (44 percent) say that they do not put much effort into their jobs over and above what is required to hold onto a job. The overwhelming majority (75 percent) say that they could be significantly more effective on their jobs than they are now.

Even more disturbing is the fact that the tendency to withhold effort from the job may be increasing. Close to six out of ten working Americans (62 percent) believe that "most people do not work as hard as they used to." A number of observers have pointed out that a considerable gap exists between the number of hours that people are paid for working and the number of hours they actually spend in productive labor. There is evidence that the gap is widening. One study conducted by researchers at the University of Michigan found that the difference between paid hours and actual working hours grew by 10 percent over the ten-year period between 1965 and 1975.

From the point of view of the country's economic needs, this commitment gap has surfaced at the worst possible time. After nearly three decades of sustained growth, America's economic machine seems to be slowing down. Unemployment has reached the highest levels since the depression, the growth in our standard of living has leveled off (and declined for some groups), and the nation is experiencing severe deficits in its budget and balance of trade, as well as renewed calls for protectionism.

Most observers agree that there is no single cause for the nation's declining economic vitality. A great deal of attention has been given to factors such as overemphasis of short-term profits, sluggish capital formation, the trade policies of our competitors, the effect of government regulation, and the disrepair of the nation's infrastructure. But much less attention has been given to the status and morale of our human resources. Although leaders in business and government frequently give lip service to the importance of "human capital," they seldom have any concrete plan for upgrading the effectiveness of individual jobholders. Not surprisingly, they focus their attention on factors that are easier to measure and control.

The growth in discretionary effort, however, has brought human resources to a position of critical importance. In an economy dominated by low-discretion jobs, it was possible to ignore intangibles such as commitment, creativity, and a healthy work ethic because they made comparatively little difference to overall effectiveness. But in an economy characterized by high-discretion jobs, mobilizing these human resources is crucial.

An Inner Need to Succeed

In explaining our economic difficulties, many people are quick to point to a failure of the American work ethic as a central cause. (We use the term "work ethic" in a purely secular sense to mean a desire to work hard and effectively for the sake of the work itself.) A survey of business and government leaders, conducted for Motorola by the public-opinion research firm of Yankelovich, Skelly and White, found virtual unanimity (87 percent) in the belief that a failure in the American work ethic is a key factor in our diminished ability to compete effectively with Japan. Many of these leaders attribute economic failure to the emergence of a new set of cultural values that stress hedonism, leisure, and self-satisfaction. These values, they fear, are antithetical to the values of hard work and commitment on the job.

Research done by the Public Agenda Foundation and others shows that this perception is inaccurate and misleading. Although work behaviors are indeed deteriorating, there is still a broadly shared endorsement of the work ethic in all sectors of the American labor force. In our survey, a majority of workers describe themselves as having an inner need to do the best job they can, regardless of pay; fewer than a third (27 percent) reject the work ethic in favor of other motivations (such as work as a purely financial transaction). Nearly two-thirds (62 percent) say they would prefer "a boss who is demanding in the name of high-quality work."

Perhaps more important is the fact that although the work ethic is strong among all sectors of the workforce, it is particularly prevalent among better-educated jobholders in high-discretion jobs. Nearly two-thirds of college-educated jobholders (63 percent) have a strong work ethic as compared with just under half (47 percent) of the jobholders with a high-school degree or less. Since the amount of discretion on the job and the level of education seems to be rising, the currency of the work ethic may very well be increasing.

One of the most striking findings of our research concerns the effect of new cultural values. Many younger jobholders bring a new set of self-development and "self-expressive" values to their work. In the 1960s and 1970s, these values were not always translated into commitment in the workplace. Many of our best-educated young people sought to fulfill their desire for autonomy, inner growth, and connectedness with nature through the pursuit of leisure. But our study shows that now that affluence can no longer be taken for granted, younger jobholders are discovering that the new values are in no way inconsistent with hard and effective work. Our findings show that expressive values actually reinforce the work ethic when people hold jobs that can serve as an outlet for self-expression and self-development. More than seven out of ten (72 percent) of the jobholders who endorse the new values also subscribe to a strong work ethic.

Liberating the Work Ethic

If many Americans have an inner need to give their best to their jobs, and if they have increasing control over their level of effort on the job, what is preventing them from giving more to their work? And what steps can be taken to encourage them to give more?

Our findings suggest that the problem, in its simplest terms, arises from the fact that managerial skill and training have not kept pace with changes in the workplace. As a result, the actions of managers blunt rather than stimulate and reinforce the work ethic. This conclusion suggests that practical solutions are possible. Our research for the Public Agenda Foundation isolates four main areas where managers can take steps to reinforce the work ethic:

☐ *Reduce disincentives.* Although a majority of jobholders want to do good work for its own sake, they feel that the workplace does not reward people who put in an extra effort. Nearly three-quarters of the labor force (73 percent)

Nothing corrodes the work ethic more than the perception that employers and managers are indifferent to quality.

say that the quality and amount of effort that they put into their job has very little to do with how much they are paid. This is an astonishing finding. Nearly three-quarters (73 percent) also believe that the absence of a close corrrelation between pay and job performance is one of the main reasons why work effort has deteriorated.

In addition, many jobholders feel little connection between the productivity of their firms and their own welfare. A study conducted for the U.S. Chamber of Commerce in 1980 found that only 9 percent of American workers believe that they themselves will benefit from improvements in productivity. To a disconcerting degree, the existing incentive systems have uncoupled the traditional link between financial rewards and effectiveness on the job. Rather than rewarding behavior that exemplifies the work ethic, managers convey the implicit message that commitment is neither necessary nor desirable. The lesson for managers is clear: those who want to reinforce the work ethic need to find some way to recognize effective behavior.

☐ *Distinguish between factors that enhance job effectiveness and those that increase job satisfaction.* We found that working Americans make a sharp distinction between factors that make their jobs more agreeable and those that motivate them to work harder. Most jobholders choose features such as lack of stress, convenient location, good fringe benefits, a clean and pollution-free work environment, and good relationships with coworkers and supervisors as those that would make their jobs more satisfying. But when asked to identify factors that would make them work more effectively, they mention "a good chance for advancement," "a challenging job," or "a good chance to develop my abilities." And many of the things that people say they want more of on their present job are motivators rather than satisfiers. This is consistent with our finding of a strong work ethic.

Enhancing job satisfaction is, of course, a laudable goal in its own right. But in difficult economic times, managers and union leaders have seen that increasing productivity is of equal or even greater importance. Our findings suggest that improvements in productivity require a stronger emphasis on job effectiveness than on job satisfaction.

☐ *Enforce high standards of quality.* Nothing corrodes the work ethic more than the perception that employers and managers are indifferent to quality. Conversely, a strict, even harsh emphasis on the highest standards reinforces the conviction that work has an intrinsic worth and meaning. Setting high standards of quality requires that a firm be ready to make sacrifices to prove that it really does want quality. Many employees reject the added pressure until they are convinced that the company, too, is willing to assume the extra hardships that higher quality can demand.

☐ *Flatten the hierarchy.* The most radical and difficult set of recommendations concerns status, authority, and fairness in the workplace. Traditional organizations maintain centralized control, with clearly specified job descriptions, hierarchical systems of authority, and sharp status and pay differences between those who manage those who do the work. Such differences reflect the assumption that "lower-level" jobholders are less central to the success of the enterprise than managers. In a high-discretion workplace, symbols of status and privilege that are not distributed in accordance with performance are seen as unfair and are likely to undercut performance. Many organizations that have been successful in winning high levels of commitment have relatively flat organization charts and status differences that are not invidious: they do not shout the message "managers are a class apart." ☐

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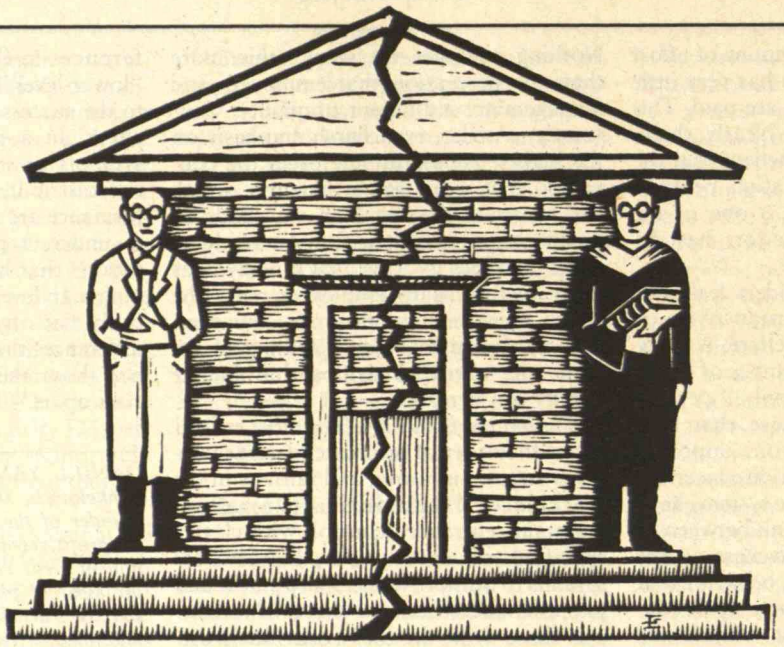
BY RUSTUM ROY

Technological Literacy: An Uphill Battle



ADD up, if you will, the cost of all the solutions that have been proposed to curb the decline in math and science education. Dr. Gregg Edwards, formerly of the Science Education Directorate at the National Science Foundation, estimates the sum to be $150 billion. So far, the U.S. House has allocated only $500 million—and the Senate and President have yet to approve that. Since any allocation is likely to be much less than $150 billion, we will clearly have to be innovative in how we use the new funds. Unfortunately, the university world, which sets educational priorities for the country, resists genuine innovations as much as any conservative board of directors or entrenched union.

For the last 30 years, the leaders of academic science and engineering have treated the problem of technological illiteracy with what amounts to benign neglect. In recent months, however, the problem has attracted nationwide attention, and the educational community will no doubt respond to the half-billion federal dollars being dangled out there for "science education." The crucial question that every policymaker and school board or university president must ask is: science education for whom? Is this crisis merely a way of saying that we have shortages of computer scientists and electrical engineers? Or is it an epidemic affecting the entire population? For whom shall we design the cure—the roughly 1 percent who become professional scientists, engineers, or doctors?

No, I submit that while this may be the group that most scientists and engineers think of first—as we did after Sputnik—it is not what the public and Congress have in mind. No further proof is needed of congressional intent than the "horror stories" that have been cited in testimony to win the passage of recent bills to improve math and science education. The tellers of these stories invariably focus on the problem of math and science illiteracy in the general population, and they offer alarming comparisons with other countries to drive the point home.

It is true that in sheer number of hours, the average student in the United States is exposed to one-fifth to one-third as many hours in science and math as her or his counterpart in Western Europe or Japan. Out of 17,000 school districts in this country, well over half have an inadequate teaching staff to cover math, science, and technology. And while the Soviet Union has 123,000 physics teachers, the United States has 10,000. Even more striking is the technological illiteracy of college seniors who have already had required science and math courses. According to a National Science Foundation study reported in *Daedalus* last Spring, the vast majority of seniors still can't solve a simple word-problem after four years of college. Given the extent of this problem, we in the science and education community would betray the country if we focused once again on just creating more or "better" scientists and engineers. The goal this time should be math and science education for all.

Those who are closest to the problem—the nation's secondary-school science teachers—have pointed to one solution. In a position paper adopted unanimously in 1982, the National State Teachers Association claims that the biggest gap in high-school science education is not in physics, biology, or even computer manipulation—but in the relationship of science and technology to society. Science, technology and society (STS) programs would focus, for example, on technology's relationship to the food-population seesaw, the consequences of genetic engineering, or the effect of computer automation on jobs.

Only by teaching science and technology in this context can we truly expect the American public to become interested in these subjects. By studying acid rain, not only does a citizen become informed about a major policy issue, but she (or he) learns what pH means and how bases neutralize acids. At Pennsylvania State University, discussing the issues of nuclear war and nuclear power has helped our philosophy and English majors grasp the principles of fission in a way that their required science courses in high school and college were never able to. Science teaching has long followed the more elitist European model of teaching pure science first with very little reference to technology. We must turn this sequence around by focusing on experience and teaching technology first, science thereafter.

In implementing what amounts to a basic restructuring of science education in the United States, there are major hurdles to overcome. The first and perhaps most serious is that there is no constituency fighting for institutional reform or the dollars with which to launch STS programs at secondary schools and college campuses. While there is, for instance, an established (and powerful) physics community fighting for financial support of physics research and education, there is no entrenched group of scholars fighting in the interests of STS.

But what, you might ask, happened to all the ambitious STS programs that

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ILLUSTRATION: ELIZABETH SLOTE

sprang up on hundreds of college campuses in the late 1960s? Such programs were launched in an effort to educate a generation disoriented and disturbed by the onrush of technological progress. Today, some 50 or 60 substantial university programs focus on science, technology, and society in one form or another. These range from "interdisciplinary" courses team-taught by members of different faculties to rare full-fledged STS departments, such as the one at State University of New York-Stonybrook, where 4,000 students a year take one or more STS courses. At Vassar and Connecticut Wesleyan, students are able to major in STS, and Cornell, Stanford, Penn State, Duke, and Lehigh offer solid interdisciplinary STS programs. But the majority of college programs now available are more limited.

The Plague of Departmentalism

Furthermore, according to faculty members who spoke at the 1983 meeting of the American Association for the Advancement of Science, most of the interdisciplinary STS programs are faltering. A survey I conducted while at the Brookings Institution this summer reaches the same conclusions. If the goal is technological literacy for a million college students, then in a decade of overwork hundreds of faculty groups have failed to attain even 1 percent of their goal, according to my survey.

The blame for this failure can be laid at the university door, specifically at the rigidity of the departmental structure in universities. Long after modern science rendered such divisions meaningless, the basic unit of power on almost all college campuses remains the department. Faculty members are well aware that doing specialized work within those departments is their sole avenue for advancement. On most college campuses, STS courses do not have the departmental structure supporting them, and as a result, faculty are not promoted for teaching STS or publishing in that field.

The history of STS programs at Harvard and Columbia—both originally funded to the tune of millions of dollars—speaks volumes. The programs were terminated after just a few years, and this was only the most extreme manifestation of academia's catatonic response to any attempt at restructuring the knowledge pie. The fledgling STS program at M.I.T. is having similar problems: announced with great fanfare as a college a year and a half year ago, it has since been reduced to an interdisciplinary program. But even under that more modest umbrella, it is having trouble bringing the many faculty stars from different departments together and attracting financial resources. Few department heads at any university are willing to allot faculty time or credits to courses taught outside their own departments. At Harvard, for instance, a student earning a Ph.D. in chemistry is discouraged from taking even one course in science and public policy for credit, even though such a course is taught by no less a distinguished scholar than Harvey Brooks, former dean of applied science and engineering.

Despite faculty resistance, some universities are making a concerted effort to restructure their curricula. At Stanford, for example, a large fraction of freshmen are permitted to take a course in "Values, Technology, and Society" as an alternative section within the "History of Western Civilization" course. The three-year-old Harvard core curriculum is another attempt to add societal relevance to standard course material. Titles such as "Dynamics and Energy: Concepts and Development," which includes a discussion of the "concepts underlying modern energy technology"; "Space, Time, and Motion," which includes "intuitive and philosophical views of space and time in the light of modern biology and psychology"; and "Chance, Necessity, and Order," which is billed as an "inquiry into the processes that create and destroy order in physical, astronomical, and biological systems"—all illustrate the effort to broaden the curriculum. Although some Harvard graduates have observed informally that the STS content in the core is little more than "cosmetic," the jury is still out. At the very least, Harvard must be lauded for making an attempt to take the broader view.

National policymakers must recognize the danger of departmentalism on university campuses and legislate accordingly. In allocating millions of dollars to improve the public's grasp of technology and its relevance to society, legislators must make special provisions to ensure that the funding will go specifically into STS programs or departments. If money intended for technological literacy is thrown into existing physics, chemistry, or biology departments, it will only reinforce the plague of fragmentation in science. Only if enough money is explicitly directed into technological literacy or STS efforts will the university system eventually respond with institutional changes. And once the universities begin the process of change, the secondary schools will follow suit rapidly—adapting teaching materials and curricula to the precollege level.

What is crucial to any effective STS program in secondary or higher education is a truly interdisciplinary faculty. Such staffs must have engineers and historians, philosophers and biochemists, political scientists and physicists working together. Indeed, as we have found at Penn State, students find it very enriching when a course is taught by faculty from each of the "two cultures." The divide between those cultures will remain and possibly worsen until the concept of STS is permanently and thoroughly absorbed into the academic bloodstream. □

Video Games, Economics of War, and the China Trade

Zen in the Arcade

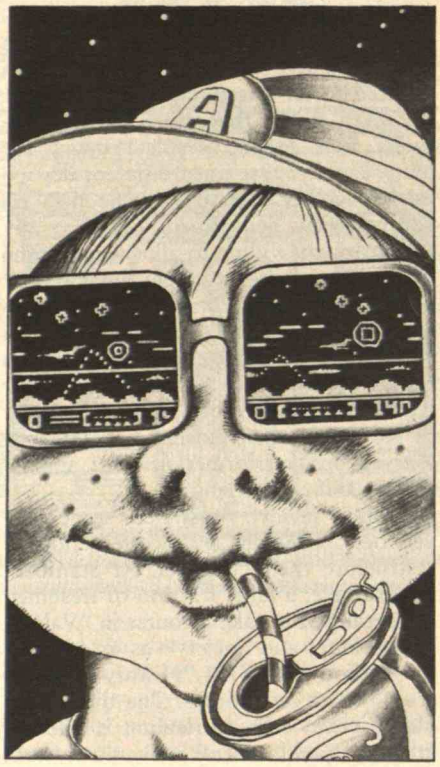
Pilgrim in the Microworld
by David Sudnow
Warner Books, 1983, $15

Reviewed by Joseph A. Menosky

No matter what one thinks of the video-game phenomenon, the games have become an unavoidable part of the cultural landscape, setting off a cascade of secondary effects that go far beyond the original purpose of entertainment. The video game has become emblematic of a new kind of skill—a high-tech mode of thinking and learning—that will create a generation of electronic whiz-kids and make America secure and economically strong again.

This skill has been promoted at all levels. President Reagan told a group of students last March that video games develop "incredible hand-and-eye coordination," and that "the air force believes these kids will be outstanding pilots should they fly our jets." (Two weeks later the president delivered his famous "Star Wars" defense speech.) Parents are barraged daily by television commercials for home video-game systems that will let their children "have fun and get smarter, too." The current massive effort to get microcomputers into the nation's school systems may stem largely from a recognition that children find the video arcade more attractive than the classroom. Indeed, much of the educational software programs now being pushed by publishing houses are clearly derived from video games, a fact touted in advertisements.

Given this situation, a critical investigation into just what sort of thinking and learning is going on in front of the flickering screen seems essential. Promoted as "the first book of its kind and in the groundbreaking tradition of *Zen and the Art of Motorcycle Maintenance*," David Sudnow's *Pilgrim in the Microworld: Eye, Mind, and the Essence of Video Skill* first appears to be such an investigation. Sudnow, a sociologist and musician, is introduced to video games while watching his son clean up on the Missile Command game in an arcade. Soon Sudnow is hooked, and he spends the rest of the book recounting his purchase of an Atari home system and his pursuit and eventual "mastery" of the game Breakout. Along the way he visits Atari headquarters in



Sunnyvale, Calif., to talk strategy with game designers, describes in minute detail his mental processes while attempting to put strategy into action, and discourses on the commercial aspects of video games and the nature of game-playing skills.

Unfortunately, almost none of this results in anything of significance. In fact, the book is little more than a self-conscious attempt to bring Eugen Herrigel's 1953 classic *Zen in the Art of Archery* into the Atari eighties by mixing some high-tech talk with philosophical assumptions care of *The Inner Game of Tennis*. Instead of the bow and arrow, the motorcycle, or the tennis court, Sudnow's arena of frustration to be overcome is the video game.

Inner Game

The crucial difference is that Sudnow's predecessors went through long and often painful personal experiences before ordering their insights and putting them to paper. Herrigel studied archery under a difficult Zen master in Japan for six years. Robert Pirsig traveled across the United States on a motorcycle, struggling with his own insanity every mile of the way. Even Timothy Galwey spent years teaching tennis before arriving at his "inner game." Sudnow reverses this process completely. He seems to have plotted his video-game experience to fit into a model of frustration giving way to mastery, undermining any genuine sponteneity. When he finally "breaks through"—supposedly overcoming his mental blocks against beating a video game—the event is almost painfully trivial.

Even this contrived approach would be acceptable if he used it to deliver insights into the video-game phenomenon. But Sudnow makes a fatal mistake: he decides to pursue the primitive home game Breakout. This keeps him from exploring the far more complex and interesting video games typically found in arcades, and from recognizing the revealing behavior of arcade players themselves.

Sudnow takes the entire book to realize that he cannot beat the game by trying to perfect "winning" strategies. Instead, he finds that by playing with pleasing patterns on the screen—forgetting about consciously striving to win—winning comes naturally. But given the formulaic nature of the book, anyone even remotely familiar with the "inner-game" approach could have predicted this conclusion.

If Sudnow had really wanted to break new ground, he would have used this lesson and his other unexamined insights to further analyze the "computer culture." For instance, Sudnow finds that an arcade game is carefully designed so that a player picks up just enough skills to overcome frustration and drop more quarters into the machine. Indeed, the arcade player does learn at a rate set by the manufacturer—but only to a point. Sudnow's ignorance of that environment prevents him from realizing that many arcade players stray from the official objectives of the game, much as he does at home. Arcade games are often subtly flawed so that by discovering certain tricks or patterns, players can escape from the preprogrammed agenda.

There's no end to the examples. An experienced Battle Zone player can stay in front of the machine until the cows come home by repeating only two easily learned procedures. The trick of "lurking" in Asteroids—clearing the screen of all but one asteroid and then hanging out at the edges blasting away at enemy spaceships as they fly overhead—allows a player to acquire a virtually unlimited number of

ILLUSTRATIONS: EUGENE YELCHIN

bonus ships. Anyone familiar with the "parking places" on the Pac-Man screen can take time out for a burger or a phone call while the machine cycles merrily away. And at the height of Donkey Kong's popularity, all serious players knew the meaning of the question "How do you get by the third elevator?" even if they didn't know the answer.

These sorts of speculations are the lifeblood of the arcade. The goal is to become a master player who can commandeer a game for hours on a single quarter, ring up huge scores, and gather an admiring crowd, much to the consternation of arcade owners and manufacturers. (In response to players' discovery of a simple but devastating scoring technique on an early version of Joust, more than one arcade owner put up a sign threatening to eject from the premises anyone using the technique.)

Thus, the arcade experience becomes one of finding ways to subvert the game rather than continually increasing skills that fall within the normal rules—a little like robbing the bank during a Monopoly game instead of putting hotels on Park Place. The most creative players change the goals of certain games completely, so that instead of, say, a high point score, they are content with a low score, long playing time, and pleasing patterns—the equivalent of playing checkers on the Monopoly board.

Electronic Warriors

The implications of this aspect of videogame playing go beyond the arcade. First, both President Reagan's enthusiasm for the arcade as high-tech military training ground, and liberal condemnations of the same, ignore the potential for mischief in a highly computerized world. The hidden lesson of the arcade—that any video game has its flaws and can be beaten—may well influence a young player's attitude toward computer systems in general. A subculture of computer users exists for whom the ultimate game consists of extralegally entering, and occasionally damaging, the data banks and information networks that constitute the highways and back alleys of the electronic world.

While graduates of the arcade may not swell the ranks of this subculture, a natural connection between the two realms is difficult to discount. That an individual crashing a computer network has been elevated to heroic status by the successful movie *War Games*, and enthusiastically cheered by legions of video-game-playing, "computer-literate" youths, suggests the reality of this connection and encourages it further. President Reagan's generation of electronic warriors might just as easily become a generation of electronic vandals. (Given the chilling implications of sophisticated information systems for privacy and democratic freedoms, that counterbalance might not be all bad.)

More immediately, the arcade experience suggests that microcomputers are being used in the nation's schools in exactly the wrong way. Most "computer-aided instruction" programs have the same qualities that kids are trying to subvert while playing video games—rigid rules and parameters. Most attempts to design "educational video games" (with dragons that eat verbs, cannons that shoot down numbers) are no improvement. If we must teach computer science to America's children—a far-reaching public-policy decision that, despite the hoopla, has yet to be truly justified—then we might as well recognize kids' desire to explore new territory.

Computer systems such as M.I.T.'s Logo encourage open-ended intellectual exploration, giving users the power to create their own rules. The compelling nature of subversion could even be used to encourage a deeper understanding of the computer itself. For example, a student could be given the opportunity to "break into" a series of progressively more complex "security systems." Such an exercise would require an increasingly intimate knowledge of computer languages and machine architecture—knowledge that would be revealed along the way. The computer would then become a flexible medium and a powerful but understandable technology rather than an expensive, glorified deck of flashcards.

Sudnow may be correct when he writes that "something vital is being dispensed" in the video arcade. The microworld is indeed a compelling, possibly dangerous, undeniably important land, and a pilgrimage may be in order. But there is little to be said for a pilgrim who stumbles across a rock and mistakes it for a temple. □

Joseph A. Menosky is a Washington, D.C.-based writer and radio producer.

The Business of Work and War

The Pursuit of Power: Technology, Armed Force, and Society Since A.D. 1000
by William H. McNeill
University of Chicago Press, 1982, $20

Reviewed by Rosalind Williams

Military history seems to attract "buffs." These zealous trivia collectors can tell you all you want to know—and often much more—about World War I aircraft, Civil War generals, Napoleon's strategies, or Revolutionary War muskets. But if war is too important to be left to the generals, neither should military history be left to the buffs. At a time when world spending on armaments approaches $500 billion annually, and when the United States and the Soviet Union together possess over 15,000 nuclear warheads, the most intellectually and morally serious type of military history is required.

William H. McNeill, who has had a long and distinguished career as professor of history at the University of Chicago, addresses this need in *The Pursuit of Power*. Although McNeill has a buff's fascination for interesting details and a scholar's reverence for footnotes, at heart he is a universal historian—an unabashed seeker of megatrends. He soars over vast tracts of the past, gazing down upon the historical landscape to view its general patterns and contours. McNeill wrote *The Rise of the West: A History of the Human Community* from this bird's-eye view, and he describes *The Pursuit of Power* as a "belated footnote" to that earlier book. It may also be read as a companion volume to his widely read *Plagues and Peoples*, an epidemiological history of civilization.

Commercialized Warfare

McNeill contends that European military power after about 1000 A.D. is "an aberration" because it merged with marketplace behavior. The commercialization of warfare, by which "market forces and attitudes began to affect military action as seldom before," started in Italy and gradually spread to the rest of Europe. No longer was warfare based primarily on the social authority of feudal knights. Instead, the values and interests of urban merchant-capitalists, who hired professional mercenaries that remained aloof from the civic population, increasingly shaped military organization.

This merging of military enterprise and the market system took place in two stages. First, city-states began to sign short-term contracts with captains who promised to hire and command troops for a fixed sum of money, sometimes for only a single campaign. By the early fifteenth century, a captain would pledge lifetime service to a particular city, which obtained a regular army of size and capability. Army and government were often bound by sentimental ties, to be sure, but their relationship was ultimately based on cash.

Indeed, McNeill shows that military history tracks general economic history. Mercantile warfare gradually weakened under the twin strains of political and technological change, so that a new era of industrialized warfare emerged. For example, during the French Revolution, the separation of the army and civil society began to break down as France resorted to mass conscription to raise a revolutionary army. At the same time, traditional military technologies began to be altered by the first Industrial Revolution—based on iron and coal—which advanced most rapidly in Great Britain. But McNeill convincingly points to the "second Industrial Revolution" of the late nineteenth century, during which the gasoline engine, electricity, steel, and chemicals were introduced, as the truly critical epoch of change in military technology. This era brought widespread advances in power generation and transmission, transportation and communications, business organization, finance, retailing—and warfare.

As McNeill describes the industrialization of warfare, things begin to sound ominously familiar. Warfare retains its links with the marketplace, but markets are increasingly perceived in terms of nationalistic competition. Politicians and publicists issue frenzied warnings about national military vulnerability and call for greatly increased arms spending. (McNeill describes the "great naval scare" in Great Britain in 1884, which led to a marked acceleration of the battleship race.) The public largely acquiesces because it fears the enemy and because military spending provides employment.

Contemporary Dilemmas

Weapons manufacturers discover that aggressive pursuit of foreign sales smooths out the sharp peaks and valleys in domestic sales. (French and British arms firms were especially active in selling equipment and factories to Russia.) Armies ask for weapons to be deliberately invented instead of buying what happens to appear on the marketplace. Weapons procurement becomes plagued by unpredictable costs and technological uncertainties, partly because the crucial test of combat is a forbidden experiment. Finally, in the two world wars of this century, vast national and then transnational bureaucracies are formed to manage military enterprise—notably lend-lease arrangements during World War II, through which the United States made weapons available to the Allies.

McNeill acknowledges that "examining the pursuit of power in former times ... will not solve contemporary dilemmas." His contribution is rather to help us understand just how serious those dilemmas are. In *The Pursuit of Power*, he shows

that the contemporary arms race is not some loathsome growth on economic life but part of the organism. According to him, economic and military development have been interwined at every stage. And likewise, the occurrence of major wars at crucial stages of industrial development, including the Napoleonic Wars and World War II, has shaped technology as we know it.

Ironically, in the early nineteenth century, leading social thinkers such as Herbert Spencer and Auguste Comte hailed what they saw as a great historical transition from "military civilization" to "industrial civilization." They thought the spirit of conquest would yield to the spirit of industry; work, not war, would be the business of society; and anachronistic, wasteful military competition would be replaced by peaceful, wealth-creating economic competition. The twentieth-century historian is far sadder and wiser. McNeill shows that military and industrial civilization have merged, and that economic and military competition only fuel each other.

Stopping the arms race therefore involves much more than stopping a few greedy "merchants of death." It requires questioning values that have seemed unassailable, such as national power and economic progress. Other values such as love of the planet and love of history need to blossom if the planet and history are to survive—but until now these have seemed fuzzy, flabby desires compared with the much stronger ones of patriotism and prosperity.

McNeill hints at some of these conclusions only briefly and cryptically. His style is straightforward, sober, even plodding. But his restraint and modesty are virtues considering the seriousness of his subject matter. Dazzling style or bold prophecy might please readers but don't solve problems. McNeill presents the evidence; the reader must ponder it and decide what to do about it. □

Rosalind Williams, an historian, is author of Dream Worlds: Mass Consumption in Late-Nineteenth-Century France *(University of California Press, 1982).*

Doing Business with the Chinese

Chinese Commercial Negotiating Style
by Lucian Pye
Oelgeschlager, Gunn & Hain, 1982

Reviewed by John Frankenstein

Written under the auspices of the Rand Corp., Lucian Pye's *Chinese Commercial Negotiating Style* joins a small but growing number of studies of the complex U.S.-China business relationship. As the best guide to the Chinese commercial labyrinth, the book will become an essential part of any China trader's kit, whether one is interested in supplying China's high-technology needs or importing Chinese goods.

But this is not a mechanical "how-to" book. Pye does not provide lists of ministries, organization charts of Chinese companies that trade with foreign countries, phone numbers for the nearest commercial attache, and the like. These change with the wind, especially in the current season of Chinese economic reform. Rather, Pye combines his profound understanding of Chinese psychology and politics with information from extensive interviews with American and Japanese business leaders who have experience in all sectors of the China trade, from electronics to grain. He uses this knowledge to explain the motivations and difficulties of Chinese commercial negotiations—the "why" as well as the "how."

And as anyone who has participated in such negotiations can attest, they are problematic. Difficulties arise, Pye suggests, because U.S. and Chinese negotiators have two different operational codes. Americans, he points out, approach negotiations in a deliberate, legalistic way. Objectives are set, fallback positions are understood, authority in the negotiating team is clear-cut, and the focus is on getting a detailed contract signed as quickly as possible. But Americans also want to understand the problems of the other party. Thus, compromise is acceptable—indeed, for most U.S. businesspeople, it is the essence of negotiations.

This style collides head on with the very different practices of the Chinese. They believe that negotiations can best be accomplished through agreement on general principles, Pye suggests—the demeaning details can be handled later. Such an agreement provides Chinese negotiators with an important tool for extracting concessions. When the going gets rough, Pye says, the Chinese can use the general agreement "to attack the other party for bad faith." In the words of one businessman, the Chinese "always put us on the defensive." This partly assuages their ambivalence about dealing with capitalistic foreigners. And the agreement provides Chinese negotiators with a bureaucratic out: if negotiations fall through, blame can be placed entirely on the foreign side.

Controlling the Agenda

Indeed, the bureaucratic setting colors all negotiations with the Chinese. To begin with, the negotiators are probably officials from a foreign-trade organization rather than the potential users of a technology. Thus, they may not have the authority to make on-the-spot decisions. They must refer any difficulties to higher authorities, often across bureaucratic lines, so communications are not only complex but also slow. Sometimes the

Chinese appear to be negotiating with two groups—foreign businesspeople and members of the Chinese bureaucracy. One American summed it up for Pye: "You have no idea what power to make decisions the people you are negotiating with have; but even worse, they don't either."

Pye attributes a good part of this confusion to the reluctance of members of the Chinese bureaucracy to accept responsibility. The political culture makes a point of separating authority and responsibility, with the second pushed down the ladder as far as it can go.

The upshot is that negotiations take time—which for Americans may mean money. But this is not to say that the Chinese take a careless attitude toward time.

They are in the enviable position of controlling the agenda: when you will visit the Great Wall, when you will have your banquet, and when you will see the negotiators (who, incidentally, do not work overtime). As Charles Freeman, an American diplomat, pointedly put it, the Chinese are "masters of the creative use of fatigue."

Negotiating Principles

Also, the Chinese may have other priorities than simply cutting a deal, such as information gathering and informal technology transfer. Because their legal system has yet to develop a comprehensive commercial component, the Chinese may tread on U.S. patents by attempting to do "reverse engineering"—working backward from a product to the technology behind it. The Chinese have a rather cavalier attitude toward protected information—they believe that foreigners maintain commercial secrets for selfish reasons, but that the details of Chinese technology are state secrets.

But the prospective China trader should not be discouraged, for Pye suggests in good Confucian style a number of useful negotiating principles:

☐ Be Patient: Remember that in China timeliness may not be next to godliness.
☐ Be Steadfast and Restrained: Constancy, dignity, and sincerity are more important than effusiveness.
☐ Avoid the Trap of Indebtedness: Remember that for the Chinese, relationships include a large measure of mutual obligation.
☐ Prevent Exaggerated Expectations: Don't oversell, for in disappointment the Chinese will revert to moralizing.
☐ Take General Principles Seriously: Don't agree to something you will want to change later. To the Chinese foreigners are unpredictable, and unpredictability is often difficult to separate from insincerity.
☐ Master the Record: The negotiators and the bureaucracy will be well prepared. A culture with a written history that goes back 5,000 years knows how to keep files.
☐ Prepare Damage-Limitations Measures and Resist Efforts at Shaming: Anticipate misunderstandings but do not prepare an aggressive defense—this will only reinforce Chinese feelings of foreign insincerity.

And perhaps most important:

☐ Know Chinese Cultural Differences but Be Yourself: No one can out-Chinese the Chinese. However, if one is aware of the intercultural dynamics of negotiations, then when difficulties arise they can at least be understood.

Pye has not only written a book of great interest to anyone concerned with China; he has also set a standard for writing about international business practices. Too much business commentary, and indeed social science in general, is wrapped up in the methodology of mail surveys and rigid rules of behavior. Pye never lets us forget that the key variables are people, policies, and cultures.

Not so long ago an acquaintance of mine, just back from Beijing after long negotiations over sale of a computer system, told me he had read this book prior to his departure. When I asked him what he thought of it he remarked, "I wouldn't have believed it, but Pye could have written the script." ☐

John Frankenstein is assistant professor of international studies at the American Graduate School of International Management in Glendale, Ariz. Formerly a foreign service officer specializing in China and Western Europe, he received a Ph.D. from M.I.T. in political science.

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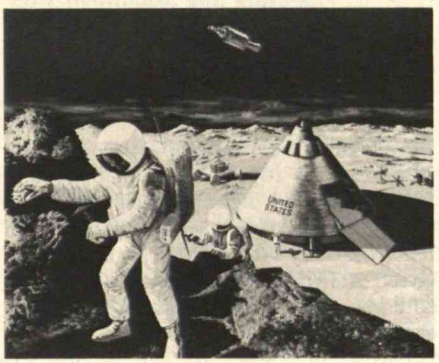
Mission to Mars: The Case for a Settlement

BY CAROL STOKER AND CHRISTOPHER P. McKAY



The time has come–again–to plan for manned expeditions to Mars. Had a NASA mission begun as suggested for November 1981, these astronauts would have returned to Earth this past August.

HISTORY will undoubtedly record the Apollo moon landing in 1969 as one of humanity's greatest achievements. That journey was a giant step forward for humankind, proving that we could explore space and expand beyond our home planet. The ensuing 15 years of sustained activity in space have totally changed our perspectives of this frontier. It now seems obvious that people will live in space, but questions remain on when, what we will do there, and how we will get there. We must decide what the next step will be.

Over the last two years, a grass-roots organization of planetary scientists and engineers has made a case for establishing a permanent settlement on Mars as the next major initiative in space. Sounds bold? So did the moon landing a generation ago. In many respects, the incentives for a Mars settlement are the same.

In the future, as in the past, the nations that explore and expand the new frontier will be preeminent. A permanent settlement on Mars would provide a focus for developing space and help stake the U.S. claim to that frontier. It would assure the country a dominant role in deciding how people develop and utilize the solar system, whether by mining mineral-rich asteroids, manufacturing products in the microgravity or vacuum of space, defending national interests, or broadening scientific understanding. Settling Mars would give the United States a strong voice in shaping space law and treaties and guarantee its international prestige.

Why Mars? Public fascination with the Red Planet is legendary. From Percival Lowell to H.G. Wells, turn-of-the-century writers so vividly described life on Mars that lay readers assumed that an advanced civilization lived there. Much of the speculation was fueled by the Italian astronomer Giovanni Schiaparelli, who published many detailed maps of Mars in the 1880s. Among the features he described were straight lines connecting darker regions across intervening light areas. Schiaparelli called these markings *canali*, or channels, which became the famous "canals" of Mars when translated into English.

CAROL STOKER is a research associate in the Laboratory for Atmospheric and Space Physics at the University of Colorado in Boulder. Beginning in January, she will be a fellow in the Advanced Study Program at the National Center for Atmospheric Research in Boulder. CHRISTOPHER McKAY is a National Research Council fellow at NASA Ames Research Center in Moffett Field, Calif. The authors were coorganizers of the Case for Mars conference in 1981 in Boulder.

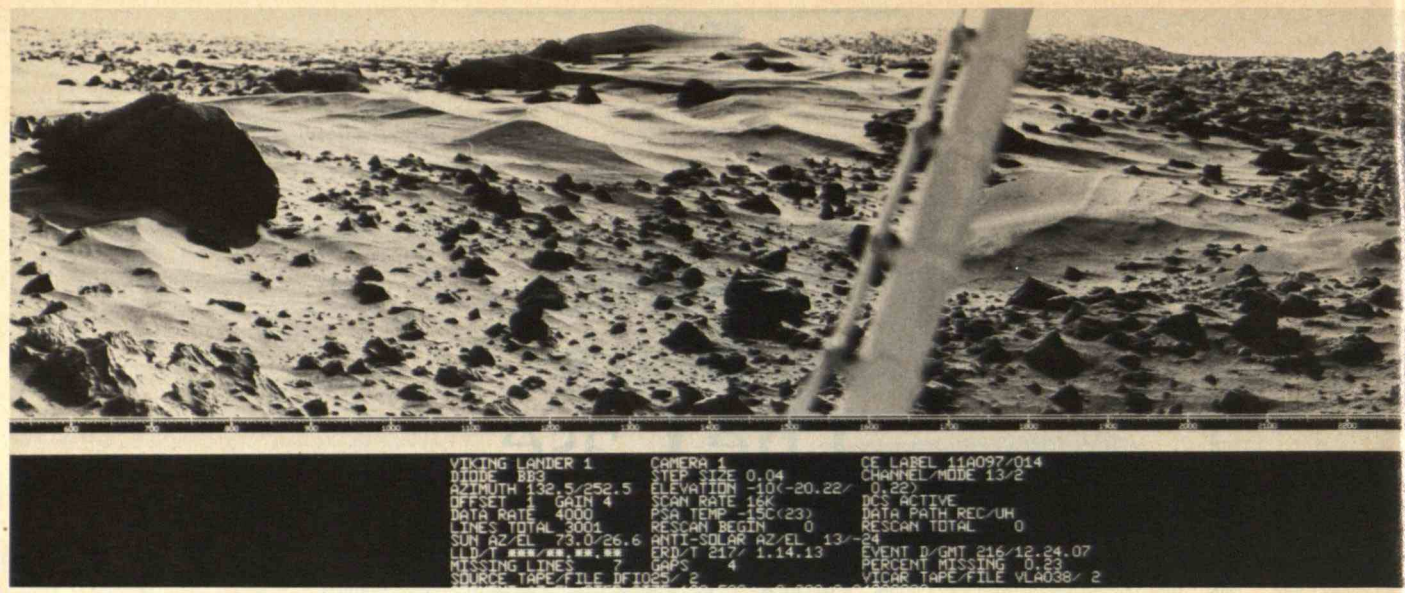
As rocket technology developed, the dream of reaching Mars entered the realm of possibility. For space pioneer Robert Goddard, the exploration of Mars was a long-held goal, and Wernher von Braun, the architect of the Apollo program, viewed the lunar landing as the first step toward a manned flight to Mars.

Of all the planets, Mars is the most hospitable and similar to Earth. Mars is the only other planet in the solar system with both an atmosphere and an accessible surface. Mercury has no atmosphere and is too close to the sun to permit human habitation. The surface temperature on Venus is 460°C—above the melting point of lead and much too harsh to allow a manned landing. By contrast, temperatures on Mars range from -120°C on polar winter nights to a high of 20°C in the southern hemisphere in summer. Unlike the giant planets Jupiter, Saturn, Uranus, and Neptune and their moons, Mars is close enough to Earth for people and materials to reach it within nine months, a reasonable time.

Unlike the moon, the only other candidate for a settlement, Mars is abundantly endowed with all the resources necessary for developing a self-sufficient base. Absent on the moon, water occurs in small quantities in the martian atmosphere and soil and in large quantities in the polar caps. Water is the most important compound needed. In addition to sustaining life, it is a source of hydrogen atoms, which are needed for chemical fuels, including rocket fuel, as well as for building materials and other useful compounds.

Mars also has the resources to produce life-support materials such as air, food, fuels, fertilizers, and building materials, eliminating the huge cost of transporting them from Earth. Although the martian atmosphere is thin—only 0.6 percent of the sea-level atmospheric pressure on Earth—and is mostly carbon dioxide, it can be processed to obtain oxygen to make breathable air. The atmosphere also contains argon and nitrogen, which may be used as a buffer gas in breathable air to inhibit combustion. Martian soil is 40 percent chemically bound oxygen, an-

ILLUSTRATION: JON McINTOSH; PHOTO: NASA



other potential source of this important element. The soil also contains sulfur and chlorine as well as the metals sodium, magnesium, and iron. Thus, construction materials, fuels, and soil for growing plants can be manufactured on the planet.

In addition, Mars holds such a strategic position within our solar system that it may one day be regarded as the St. Louis of space. Mars is the gateway to the outer solar system and the main belt of asteroids between Mars and Jupiter. Asteroids are solar-system debris that were not incorporated in the formation of the planets. Some are rich in iron, nickel, and possibly other elements that are relatively rare on Earth. Other asteroids may be rich in volatile compounds such as carbon, oxygen, and hydrogen that can be used to make breathable air and fuels for future space-based operations. The two moons of Mars, thought to be asteroids captured by the planet's gravitational pull, could be critical proving grounds for asteroid mining techniques.

For scientists interested in planetary evolution, Mars remains a source of fascination. Despite the experiments performed by the Viking mission in 1976, the question of whether life exists on Mars has still not been completely answered. Even if contemporary life forms are absent, perhaps life evolved in a past, more hospitable climate. Mars offers a rich field for planetary biologists to explore.

Over a decade ago, NASA actively studied and planned a manned mission to Mars. The idea lost support when the agency's funding was cut back, but it is now drawing renewed interest. George Keyworth, the president's science advisor, recently suggested that it was time for the United States to think about new directions for the space program as ambitious and bold as the Apollo program. A Mars settlement would certainly qualify. Moreover, establishing a long-range goal for the space program would help ensure continuity in funding and widespread popular and political support. Such continuity has been sorely lacking in the U.S. program over the past decade.

Given recent advances in technology, a single manned mission could be staged for one-half to one-third the cost (in 1981 dollars) of the Apollo program. Such a mission would make use of the space shuttle and the proposed space station, projects that top NASA's priority list. With these and other projects under development, the Mars settlement is within reach of today's technological capabilities. Given a firm national commitment, we could be there by the beginning of the next century.

Scouting the Planet

The first step in planning a martian settlement is to investigate the planet's natural resources. Although the 1976 Viking mission to Mars returned a wealth of data about the planet, scientists lack the detailed information necessary to select a site for a permanent base. Such a site must be close to water, fuels, minerals, and building resources and situated so that reliable communications can be established with Earth. The site must also be close to scientifically interesting regions, and be flat and solid enough for a spacecraft to land.

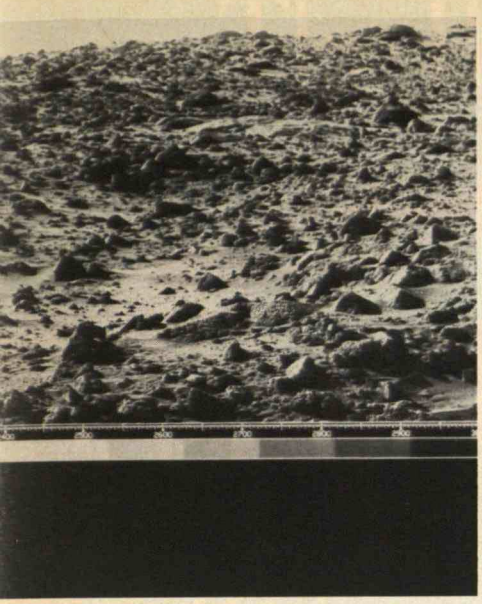
Although water, a key resource, is present on Mars, it is scarce compared with Earth's supplies. The only large known sources of water are the polar caps, but they are not ideal locations for a manned base because of extremely low temperatures and constant darkness during winter. However, scientists believe that large reservoirs of underground water in the form of ice or permafrost may extend to Mars' lower latitudes. The small amount of water vapor in the atmosphere—0.3 percent—is also a potential source of water.

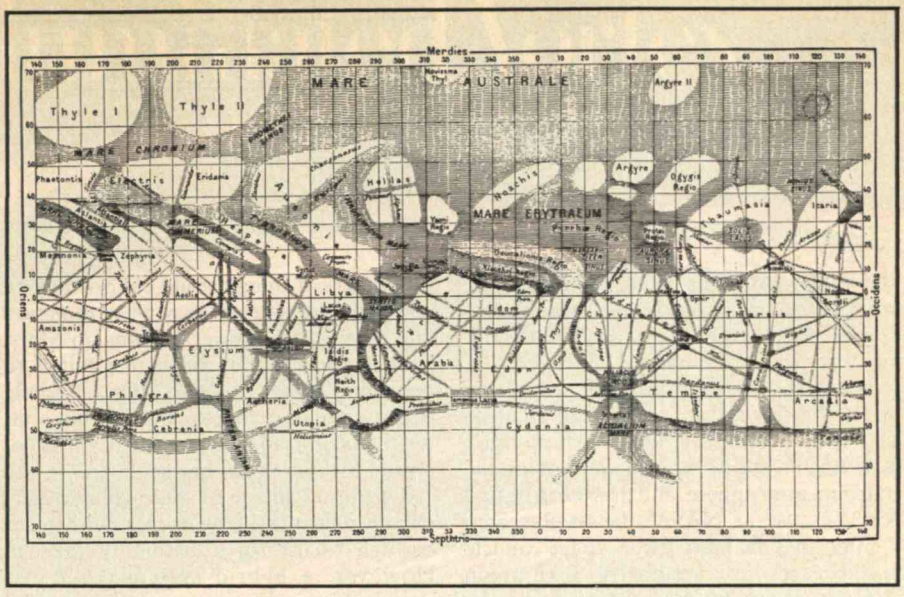
The surface of Mars can be mapped for water and mineral resources at low cost with a spacecraft that orbits the planet's poles. NASA has already designed such a mission, called the Mars geoscience/climatology orbiter. It carries a gamma-ray spectrometer—an instrument that records emissions from radioactive isotopes and from the interaction of cosmic rays with atoms in the planet's surface soil to determine its composition. Atmospheric water vapor will be measured by detectors tuned to look at the infrared emission and absorption features of water. NASA estimates that the mission will cost $100 million—by comparison, the Viking mission to Mars cost over $2 billion. Costs will be low because the experiments take advantage of technology developed for other missions, and because the spacecraft itself is based on production-line satellites for orbiting Earth.

Once prospective base sites are identified, samples of martian soil should be collected and returned to Earth for analysis. Samples could be obtained by unmanned vehicles or by a temporary manned lander, just as lunar samples were collected. Scientists can analyze these materials on Earth and then devise manufacturing processes to take advantage of them so that initial manned missions can begin manufacturing immediately.

The natural resources available on the two martian moons, Phobos and Diemos, deserve attention as well. If the moons are asteroids, then they may contain valuable, even rare, minerals unobtainable on the surface of Mars. Dr. S. Fred Singer, professor of environmental sciences at the University of Virginia, suggests establish-

PHOTO: NASA





The martian landscape, photographed by the Viking lander on August 3, 1976, greatly resembles the deserts on Earth. The martian soil and atmosphere contain many resources necessary for developing a self-sufficient base, including water, oxygen, hydrogen, and metals.

The Red Planet has long fascinated the public, especially the possibility of life there. This map, drawn in 1887 by an Italian astronomer, features many straight lines that he labeled canali, or channels. These became the famous "canals" of Mars.

ing a manned "beach-head" on one of the moons before attempting a landing on the planet. From this base, astronauts could operate a fleet of remote-controlled rover vehicles to collect soil samples from Mars. One advantage of such a plan is that it avoids contaminating Mars with terrestrial organisms and Earth with martian organisms—if they exist.

Outfitting the Ships

The trip to Mars would use both the space shuttle and NASA's proposed space station for a transportation network. A manned space station in low-Earth orbit with facilities for building structures in space is a key intermediate step on the path to Mars. The size and complexity of spacecraft needed to build the Mars settlement will make it difficult if not impossible to launch them preassembled from the ground. Instead, spaceships will have to be assembled at the space station from components delivered by the shuttle. NASA expects to have the space station operating in the 1990s.

Both manned ships and unmanned cargo ships could be used in a voyage to Mars. Manned ships, which must support a crew over a nine-month flight between the two planets, will require heavy, complicated, and expensive habitation and life-support equipment. Everything not absolutely necessary for the crew on the Mars transit could be sent ahead on unmanned cargo vehicles, which can be relatively simple and inexpensive.

The choice of a propulsion system will affect the designs of both manned and unmanned vehicles. Conventional rockets launched from the surface of the Earth use chemical propellants, frequently combining liquid oxygen and liquid hydrogen to produce a powerful thrust. This is the only propulsion technology that has been adequately tested in space that has enough thrust to overcome gravity at Earth's surface. However, it consumes large amounts of fuel, posing problems for a long interplanetary flight. The fuel for the return trip must be carried on board, which further increases the weight of the vehicle and raises its fuel requirements. For each ton of fuel needed for the return trip, 5 to 10 tons of fuel are needed to boost this extra propellant to Mars.

More efficient propulsion systems would reduce the fuel costs of exploring Mars. The solar sail is an attractive possibility for propelling the unmanned cargo vehicles, which can travel slowly. Solar sails, first proposed by Russian researchers Konstantin Tsiolkovsky and Fridrikh Tsander in the early 1920s, use no rocket engines and expend no fuel. Instead, photons radiated from the sun strike a sheet of shiny material such as aluminized plastic film to provide the thrust. The sail must be one to two kilometers on a side to gather enough sunlight to create reasonable propulsive force. The World Space Foundation (WSF), a private research and development organization in Pasadena, Calif., has designed a solar-sail-propelled vehicle and plans to launch a prototype by 1987.

Robert Staehle, an aerospace engineer with NASA's Jet Propulsion Laboratory and president of WSF, has outlined a mission to Mars using a fleet of remote-controlled solar-sail cargo vehicles. Fifty to sixty shuttle payloads would be needed for the mission, of which about twenty would be used to construct a fleet of two-kilometer-square sails. These could tow over 400 tons of equipment and supplies—enough to support an initial Mars landing crew of eight—from a staging area in low-Earth orbit to Mars. The trip to Mars would take almost four years, but the solar-sail vehicles could also serve as a continuous ferry for samples and supplies between Earth and Mars.

Another promising technology for cargo ships is electric propulsion, or "ion drive." This technology uses electric power to transform a propellant into charged particles, which are then accelerated by an electric field and expelled at high velocities. The thrust of the electric-propulsion engine depends on the rate at which the ions are expelled, which in turn depends on the size of the electric power supply. Currently available power supplies provide an engine thrust that is low compared with chemical propulsion. However, an ion-drive engine consumes only one-tenth the fuel of a chemical engine to produce the same propulsive force.

Born in the mid-1950s, the concept of electric propulsion has inspired small-scale research and development work for decades. In 1970, NASA put a satellite with ion thrusters into orbit and test-fired them over a ten-year period. Early electric propulsion systems used nuclear reactors to provide the power, but the trend since

the mid-1960s has been toward using banks of solar panels. Solar-powered electric propulsion (SEPS) may well be the optimal system for unmanned Mars vehicles. Propellants for solar electric propulsion are either metallic conductors such as mercury or ionizable fluids such as argon gas. Argon makes up 1.6 percent of the martian atmosphere and has been tested for SEPS use at NASA's Lewis Research Center in Cincinatti. If a space vehicle could refuel for a return trip with argon derived from Mars' atmosphere, the weight that must be launched from Earth, and hence mission costs, would be reduced.

The solar panels from a SEPS engine could also be used to generate electricity when a spacecraft is parked in Mars orbit. As first proposed by Peter Glaser of Arthur D. Little, Inc., in Cambridge, Mass., this electrical energy could conceivably be converted to laser or microwave radiation and beamed to receiver stations on Mars. Such a process may be better suited to providing power on Mars than on Earth, because the thin atmosphere will not scatter the beams and there is clearly less potential for biological harm.

The disadvantage of solar-sail and electric propulsion systems is that neither has enough thrust for a planetary takeoff. However, a hybrid system could use chemical propulsion to escape gravity and solar sails or electric propulsion for interplanetary flight. Fuel requirements for the hybrid system would be several times lower than for chemical systems alone.

To minimize the crew's exposure to the potentially harmful effects of space flight, the manned spaceship must travel at speeds faster than are possible using solar sails or electric propulsion. Therefore, conventional chemical propulsion such as that used on the space shuttle is the best option in the near future for manned vehicles.

Once the manned spaceship arrives at Mars, fuel could be saved by "aerobraking"—using the upper layers of the planet's atmosphere to slow the vehicle's passage. Aerocapture occurs when the craft sheds enough of its initial velocity to enter an orbit around the planet. The conventional breaking method, in which forward-facing rockets slow the spacecraft, consumes a great deal of fuel. A vehicle using the aerocapture technique could potentially put twice as much payload weight into Mars parking orbit for the same launch cost as could a vehicle using rocket engines alone. A mission using both aerocapture and solar-sail or

"The Moon Is Not the Ultimate Goal"

It's been said that if all the spaceships ever proposed for traveling to Mars were actually built and then laid end to end, the result might reach halfway to the intended destination. That's stretching things a bit, but many proposals have been advanced for traveling to the Red Planet.

Wernher von Braun, who pioneered the development of rockets that eventually propelled astronauts to the moon, made the first detailed analysis of a Mars mission in 1952. His engineering blueprint, published as the *Mars Project*, called for a shuttle-like vehicle that would ferry huge amounts of equipment from Earth to an orbit in space, where it would be assembled into ten spacecraft. The ships, each carrying a crew of seven, would then travel in convoy, and the landing party would spend 400 days on the martian surface.

In the early sixties, when the unswerving focus of the Apollo program seeded boundless excitement for space exploration, the idea of a manned mission to Mars received serious attention. In 1963, the American Astronautical Society sponsored what was called the first planning symposium, which drew 800 scientists and engineers.

The next year von Braun, who was then director of the Marshall Spaceflight Center in Huntsville, Ala., organized a similar conference. "Although the nation is firmly dedicated to achieving a manned lunar landing in this decade, landing on the moon is not the ultimate goal," he declared. "Man will travel beyond the moon to explore the solar system. When, I do not know. But it will take all the disciplines of technology and management to push the frontiers of space into the backyards of the planets."

By the time of the 1969 Apollo moon landing, space engineers had developed a "NASA standard man-to-Mars mission," writes James Oberg, an engineer at the Johnson Space Center in Houston, in *Mission to Mars*. "For many space workers, the moon was only a detour, a temporary distraction from the serious business of getting to Mars."

However, politics intruded. The expensive war in Vietnam aroused the anger of Congress, and President Nixon viewed a costly space program as a potential liability. NASA saw its budget clipped and its horizons foreshortened.

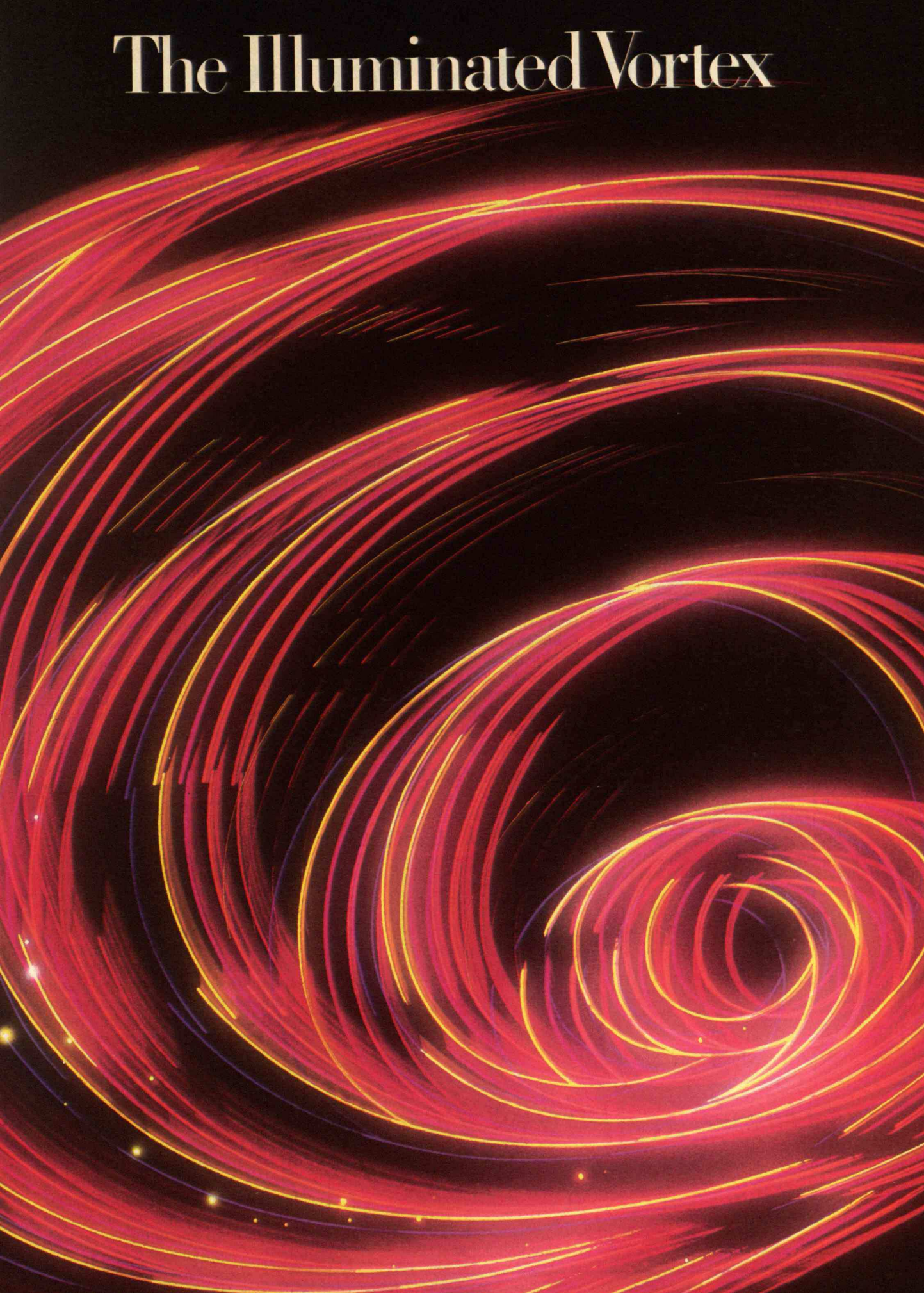
Officially, any plans for a manned mission to Mars retreated to the back of the file drawer. But unofficially, individuals continued to develop plans in private, biding time until the political winds freshened in their direction.

In the spring of 1981, this underground of Mars enthusiasts emerged at a conference organized by Carol Stoker, Christopher McKay, and a number of other students at the University of Colorado. About one hundred people met for three days, drawing up ideas for everything from propulsion systems to martian farms. The participants also identified many of the critical problems and outlined areas for further research.

"Among all these plans are bound to be ideas useful when the time comes again to officially plan a NASA man-to-Mars expedition," writes Oberg. "If not, there is little doubt that their plans have been carefully translated into Russian."

Mars enthusiasts are continuing their efforts today. The Mars Institute, recently started by the Planetary Society, will sponsor courses at various universities for studying a manned Mars mission. And a Second Case for Mars conference will meet in Boulder in July 1984.—*Jeanne McDermott* □

The Illuminated Vortex



The Illuminated Vortex

Understanding how the in-cylinder flow of the fuel-air mixture is influenced by chamber geometry provides a key to improving engine performance. By applying a laser measurement technique, a researcher at the General Motors Research Laboratories has gained new insight into the behavior of the flow.

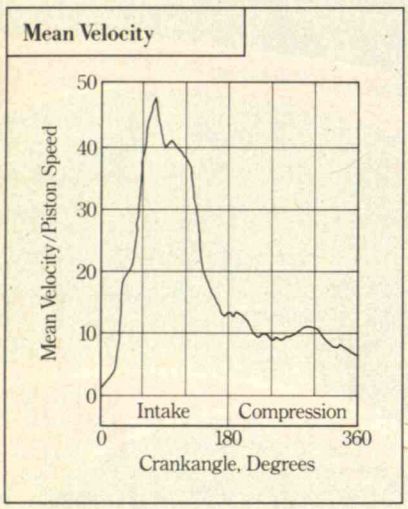


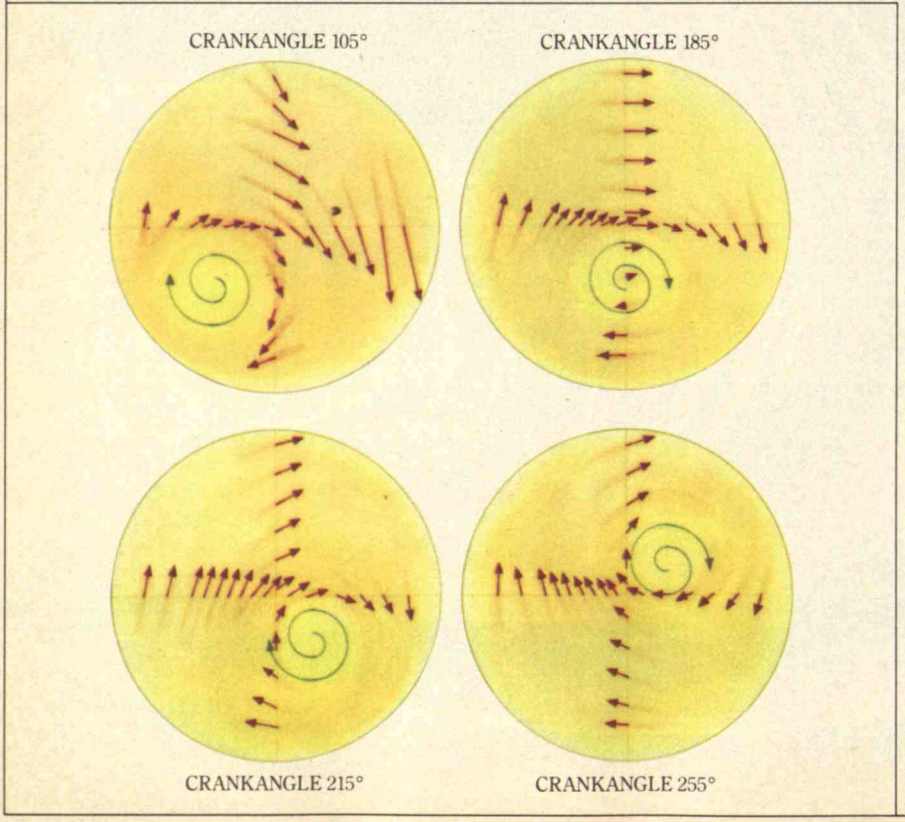
Figure 1: History of mean velocity at a single engine location.

Figure 2: Panoramic view of engine flow patterns. With changing crankangle, the center of rotation precesses from the cylinder's lower left quadrant to its upper right quadrant.

THE FLUID motions inside engine cylinders have considerable influence over the progress of combustion. Mixing of air and fuel, combustion rate, and heat losses from the cylinder are all important transport processes strongly dependent on fluid motions. The motion inside the cylinder has two components. Mean velocity influences the transport of momentum, energy, and species on a cylinder-wide scale, while the turbulence component influences the same phenomena on a local basis. The in-cylinder flow field depends primarily on the geometry of the cylinder and inlet port. Hence, decisions made in the engine design stage exert a controlling influence over the flow. But before questions about how different geometrical features affect the flow field can be answered, the problem of how to measure the flow must be solved. By applying Laser Doppler Anemometry (LDA), Dr. Rodney Rask, a researcher at the General Motors Research Laboratories, has obtained detailed measurements of the flow field.

LDA is a technique in which two focused laser beams pass into the cylinder through a quartz window. In the minute measuring region where the laser beams cross, a regular pattern of interference fringes is created. As the 1-micron particles, which have been added to the engine inlet flow, cross the measurement region, they scatter light in the bright fringes. In Dr. Rask's LDA system, the scattered light is collected by the same lenses used to focus the laser beam, and measured by a photomultiplier tube. The resulting signal is processed electronically to determine the time it takes a particle to traverse a fixed number of fringes. Since the fringe spacing is a known function of the laser beam crossing angle, this transit time provides a direct measure of velocity.

During operation of the LDA, measurements of velocity as a function of engine rotation (crankangle) are made at a number of locations within the cylinder. The instantaneous velocity at each point must then be separated into mean and turbulence components. The simplest technique is to declare that the mean velocities for all cycles are identical and ensemble average the data. However, this approach ignores the cyclic variation in the mean velocity. Another technique looks at individual cycles and uses a variety of methods, including sophisticated filtering, to split the instantaneous velocity into its components. This



approach is consistent with the LDA measurements, which clearly show that the mean velocity does not repeat exactly from one engine cycle to the next.

Differences in the flow field from one cycle to the next can seriously compromise engine efficiency. Near the end of the compression stroke, it is important to maintain a consistent velocity at key cylinder locations (e.g., at a spark plug). Dr. Rask's LDA measurements have identified design features that control cyclic variability.

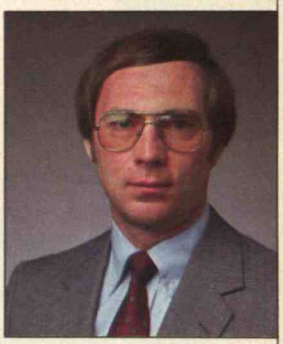
FIGURE 1 shows mean velocity measured at a single location during an engine cycle. High velocity exists during the intake stroke when the inlet flow is rushing through the narrow valve opening. This jet-like flow into the cylinder causes large velocity differences between adjacent cylinder locations and produces strong turbulence. As the end of the intake stroke is approached (180 degrees in Figure 1), the levels of both mean velocity and turbulence drop rapidly. This decrease is a result of the changing boundary conditions for the cylinder—from strong inflow to no inflow. During the compression stroke the flow field evolves, but it undergoes no drastic changes. However, in a high-squish chamber, where the flow is forced into a small bowl in the piston or cylinder head, considerable turbulence is generated near the end of the compression stroke.

Measurements from many cylinder locations are necessary to make the flow field understandable. Figure 2 shows four flow patterns covering a period from near the end of intake into the compression stroke. Note the strong vortical flow, with the center of the vortex away from the cylinder center and precessing with changing crankangle.

By experimenting with geometrical variables, Dr. Rask has gained new understanding of phenomena observed in operating engines. The resulting knowledge has guided the design and development of new engines with a minimum of trial-and-error testing. The LDA findings are also being used to validate and calibrate engine flow computer models under development.

"From our measurements," Dr. Rask states, "we have been able to deduce how changes in the geometry of the port and combustion chamber modify the velocity field. These flow field effects are now being used to help designers tailor engine combustion for optimum performance."

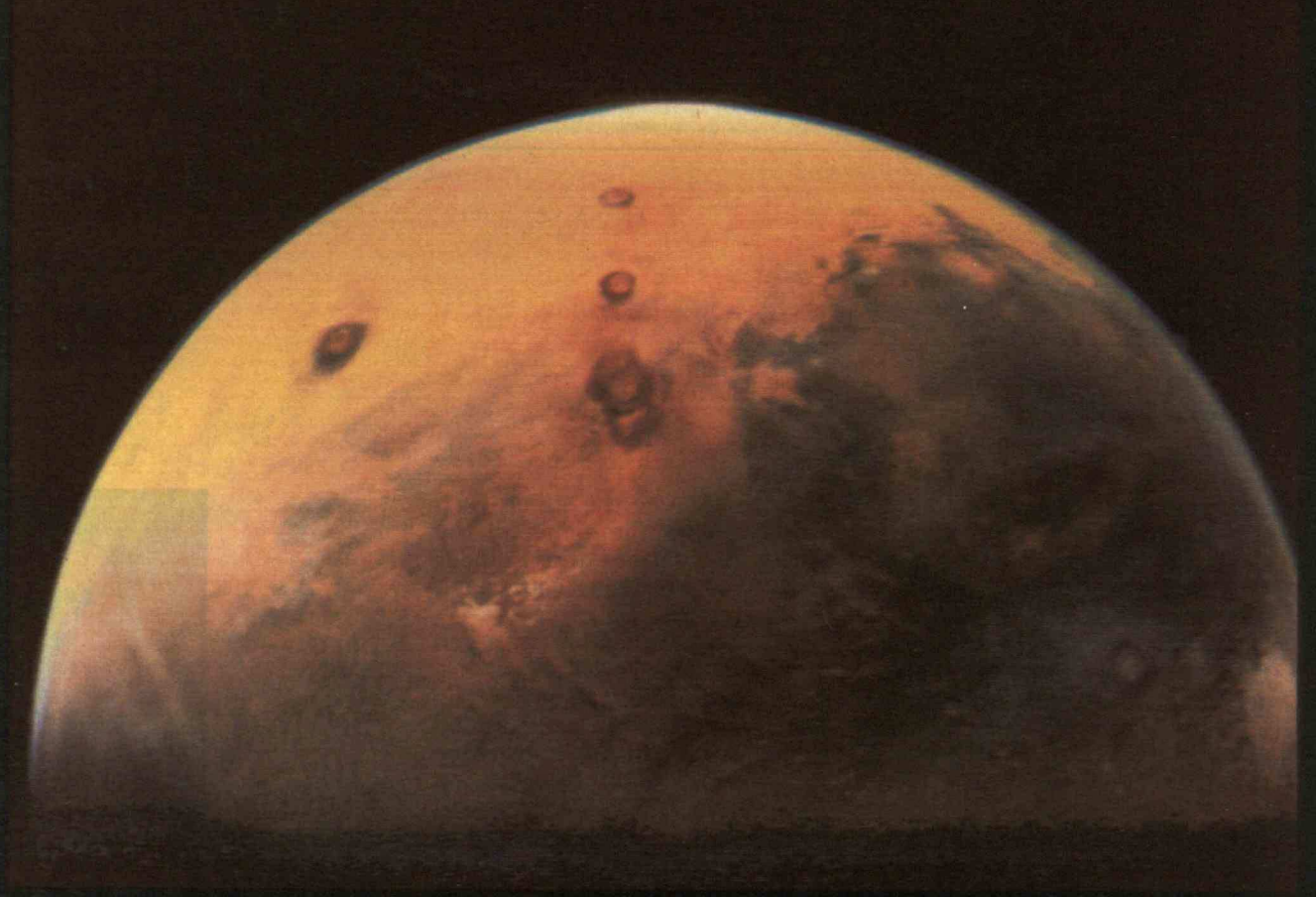
THE MAN BEHIND THE WORK

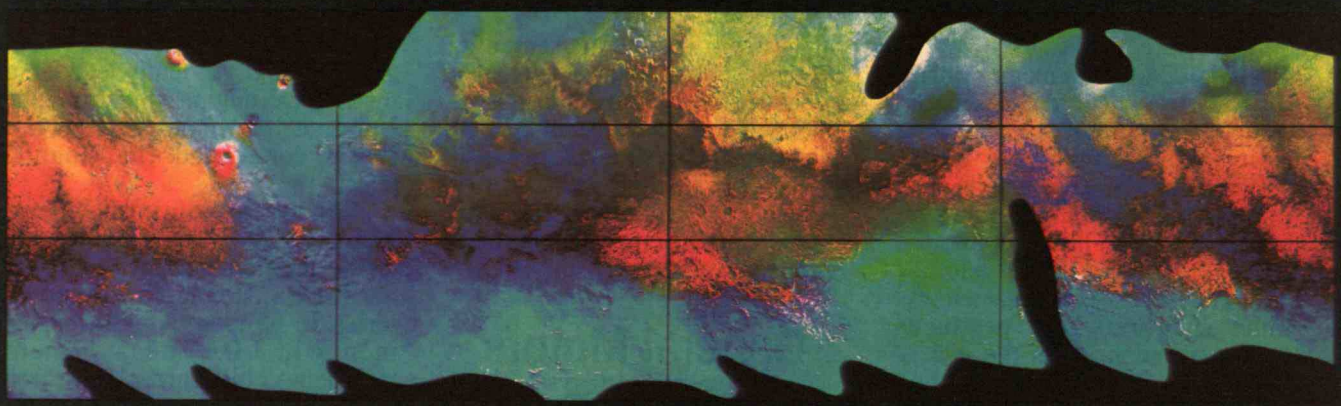


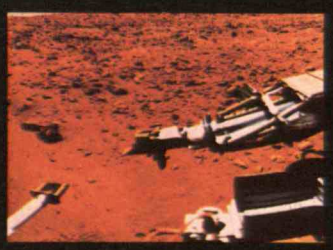
Dr. Rodney Rask is a Senior Staff Research Engineer in the Fluid Mechanics Department at the General Motors Research Laboratories.

Dr. Rask received his undergraduate and graduate degrees in mechanical engineering from the University of Minnesota. His Ph.D. thesis concerned the Coanda effect.

Prior to joining General Motors in 1973, Dr. Rask worked on the design of nuclear reactors at the Knoll's Atomic Power Laboratories. In addition to further refinements in LDA measurement techniques, his current research interests include computer simulation of engine systems, with special emphasis on the intake manifold.







Top: Here photographed as Viking closed to within 348,000 miles, Mars looks as it would to approaching astronauts. Clearly visible are the Tharsis mountains, three volcanoes that tower 12 miles above the surrounding plain.

Center: This computer-colored view of the martian surface at the equator reveals iron oxide (red), basalt (blue), sand (yellow), and ice and fog (turquoise).

Bottom, left: Viking's mechanical scoop collected soil for chemical analysis. Center: Olympus Mons, Mars' largest volcano, hints at the planet's active geologic history. Right: This canyon, Valles Marineris, would swallow Arizona's Grand Canyon. Other vast networks of canyons suggest that water once flowed freely.

PHOTOS: NASA; U.S. GEOLOGICAL SURVEY

SEPS cargo vehicles would reduce fuel requirements and help offset the development costs of these new propulsion systems, particularly if there is a long-term settlement on Mars.

Over the Long Haul

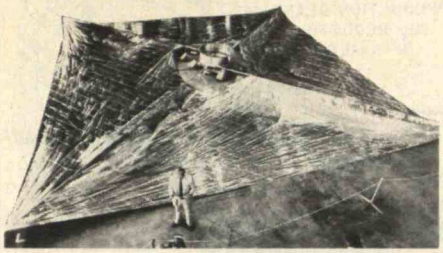
The trip to Mars will last longer than any manned mission ever launched. Each interplanetary haul will take nine months, and the crew will have to stay a minimum of one year on Mars to take advantage of the optimal alignment of Mars and Earth for traveling. Thus, the shortest trip will last over two and a half years, much of which the crew will spend in the spaceship.

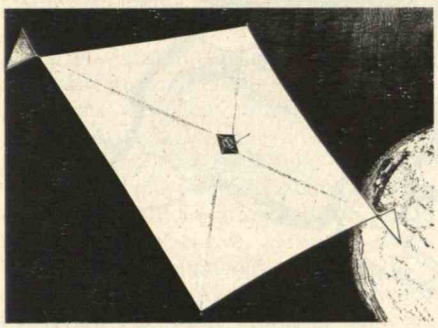
During such a long voyage, the crew must feel comfortable. Unfortunately, the larger the spaceship, the more expensive it is to launch. But Thomas C. Taylor, a consulting engineer from Taylor Associates of Los Angeles, has proposed a low-cost way to build the crew's quarters. While working on the oil pipeline in Point Barrow, Alaska, where packing crates for oil-rig supplies were used as dwellings and clubhouses, Taylor recognized the value of recycling materials. He suggests saving and retrofitting the shuttle's external fuel tank for life-support facilities for a manned ship. This tank is lightweight and extremely roomy; in fact, it is five times larger than *Skylab*, which housed three astronauts for 84 days. Best of all, the tank would already be in space—it now drops off from the shuttle when its fuel is expended and burns up in the atmosphere. But if the tank were boosted into a slightly higher stable orbit, it could be retrofitted for Mars transit at the space station.

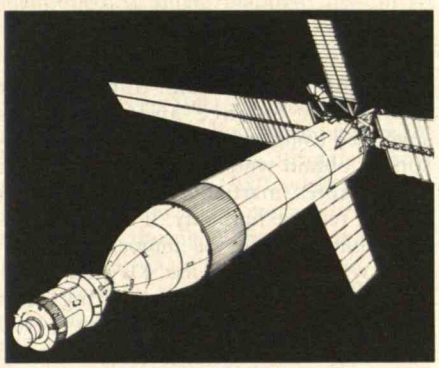
Several retrofitted tanks could be joined together to accommodate larger crews. Furthermore, if crews found the deleterious effects of microgravity too severe, several tanks could be connected in a donut-shaped configuration and rotated to produce artificial gravity.

Life Support

Meeting the human requirements of long interplanetary flights is one of the most difficult challenges. Astronauts must have adequate diets and avoid overexposure to toxic substances and radiation. They must adapt to space sickness and the lack of gravity. They must deal with the psychological stress associated with isolation and confinement. And when they land, they must readapt to a high-gravity environment.







Solar sails, driven by photons from the sun, can haul cargo to Mars. The World Space Foundation plans to test this prototype (top) in space by 1987. The final sail (center) will be two kilometers on a side to catch enough photons.

Cargo ships can also use a solar-electric propulsion system. This SEPS-powered ship (bottom), made from a used space-shuttle fuel tank, is docking with a manned lander. The SEPS solar panels, which must be much larger than pictured, convert a propellant into charged particles that are expelled at high velocities.

Each crew member will need four pounds of water, three pounds of food, and two pounds of oxygen a day. Life-support systems can be "open," so that all materials are provided fresh and used only once, or "closed," so that waste products are processed and recycled. The open system is simple and reliable but its cost climbs as the trip lengthens. The closed system may require heavy, complex, and fail-safe recycling equipment but may weigh less for long missions.

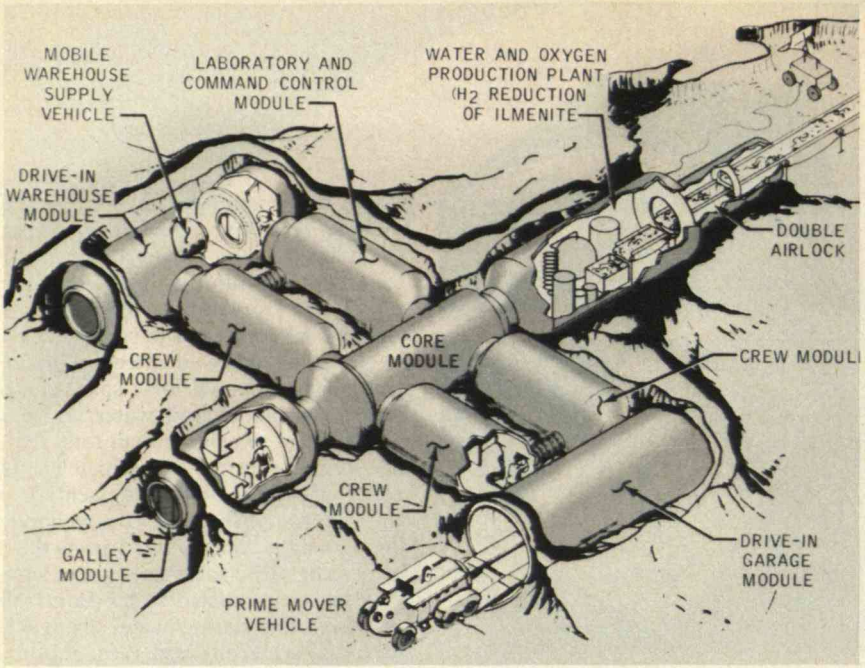
Current technology for closed and semiclosed life-support systems is inadequate for long stays in space, but both are receiving renewed attention because they will be essential for a space station. Partial recycling of food, water, and waste will be easier to achieve than total recycling. Revitalizing the air, which includes removing carbon dioxide, is essential, and can be accomplished with the technology already on the shuttle. The Soviets recycle 50 percent of a spaceship's water simply by recovering exhaled water from cabin humidity. Recovering water from wash water and urine, although difficult, can be done using a complex procedure of distillation and filtration. Recycling solid waste to grow food is the most expensive and difficult process of all and will probably not be cost effective.

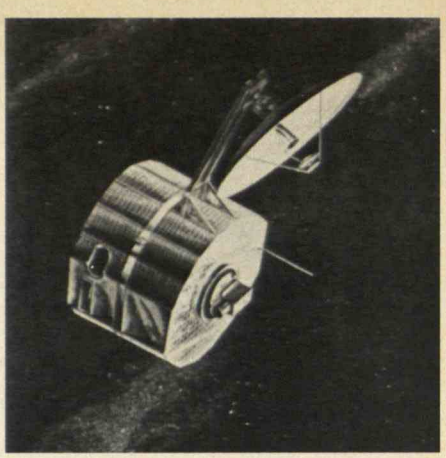
Space takes a toll on human health—but just how serious a toll remains to be seen. In microgravity, the heart and other muscles atrophy. Although exercise can help maintain muscle tone, designing a program that adequately uses all the muscles is difficult. The Soviets, who have considerable experience with weightlessness, combat the problem with elastic space suits that force the muscles to work continuously.

Perhaps a more insidious problem is the loss of calcium from weight-bearing bones. Physicians are not certain why this occurs, but they have noticed that patients bedridden for months in a body cast suffer the same loss. A 10 percent loss of bone calcium is considered serious, and astronauts may lose up to half a percent a month. Some drug therapies have been suggested to halt or at least slow this condition, but they remain untested. Fortunately, loss of calcium stops and reverses on return to a high-gravity environment. However, a crew could be highly susceptible to bone fracture for a period after landing on Mars.

Another major health concern is the high amount of radiation astronauts will encounter throughout the flight to Mars. Astronauts will be exposed to at least 40 rems per year of harmful background radiation from the sun and other stars. In addition, solar flares deliver upward of 60 rems of radiation in an average year and several times that amount in a bad year. Federal health standards allow a total ex-

PHOTO: RICHARD DOWLING, WORLD SPACE FOUNDATION; DRAWINGS: JEAN-LUC BEGHIN, WSF; CARTER EMMART





A permanent Mars base must be near water, fuels, minerals, and building resources, and be situated to allow communication with Earth. The site must also be close to scientifically interesting regions. An early NASA scenario thought a permanent base might look like this (left). Before Mars is settled, its surface should be mapped for water and minerals using NASA's proposed geoscience/climatology orbiter.

posure of 300 rems over a 20-year career. For protection against short, fierce solar flares, a Mars ship will need a "storm cellar" designed to place as much mass as possible between the crew and the sun. The radiation hazard might favor selecting older astronauts, or at least those past childbearing age.

To maintain astronauts' mental health, Dr. B.J. Bluth, a space psychologist at California State University in Northridge, suggests sending a minimum of seven crew members on any mission. The crew should be composed of an odd number of personnel to prevent deadlocks in command and ensure democratic decision making. It should include both men and women of different professions, backgrounds, and personalities who are taught to withstand the demands and stresses of the mission, and to work together equitably and develop a chain of command and protocol. While the Soviet space program has had considerable success in teaching astronauts how to manage stress, this type of training has been lacking in the U.S. space program.

Settling In

When manned ships first arrive on Mars, the crew's first priority will be to establish a permanent base as self-sufficient as practical. For safety reasons, the pioneering crew should go to Mars with enough food and supplies to last the entire mission, but later crews can rely on locally produced supplies. The martian water supply will have to be tapped immediately. Thomas Meyer of the Boulder Center for Science and Policy has suggested using conventional air compressors to obtain water. At typical nightime temperatures, martian air is at nearly 100 percent relative humidity. If it is compressed while keeping the temperature constant, water will condense. Meyer and colleagues estimate that extracting each kilogram of water will require up to 400 kilowatt-hours of electricity to drive the compressors. Although supplying that amount of energy may be difficult, the atmospheric supply of water is inexhaustible because water is replenished through evaporation at the poles.

Water could also be extracted by heating martian soil. Dr. Benton Clark of Martin Marietta Co. in Denver estimates that 10 to 100 metric tons of water could be extracted per month, even from dry martian soil, using a 50-kilowatt heat source. Finally, the ice reservoirs at the poles or the permafrost in the lower latitudes could be mined with excavating or blasting equipment.

An air supply will be needed inside dwellings and workplaces. Breathable air must have enough oxygen pressure and an inert buffer gas that inhibits combustion. Carbon dioxide, the primary constituent of martian air, will liquify if the air is compressed and can be processed to obtain oxygen. Nitrogen and argon, the other major constituents of the martian atmosphere, could be used as buffer gasses after the carbon dioxide is removed. Since the buffer gas is not directly consumed, it would not have to be continuously resupplied.

Solar panels could provide power for the base, either from the orbiting SEPS spacecraft or on the ground. A small nuclear fission reactor is also a realistic power option. Although the equipment for both systems must be carried to Mars, neither requires frequent resupply.

Fuels for the return trip could possibly be made on Mars or its moons. An argon-propelled SEPS ship could be refueled using argon from martian air. The chemical propellants burned during takeoff and landing could also be resupplied if enough water is available. Solar or nuclear-generated electricity could be used to split the water into oxygen and hydrogen for the rocket fuel. Hydrogen could also be reacted with carbon dioxide to produce methane, which can be used as fuel.

Martian soil could be the basis for greenhouse agriculture. Although the soil contains sodium and magnesium sulfates as well as sodium chloride, these salts can be diluted with sufficient washing. Adding organic material from human waste will improve the soil's fertility. And the nitrogen in martian air can be reacted with hydrogen to produce an ammonia-based fertilizer.

Standard food crops could be grown in above-ground greenhouses. Penelope Boston, a biologist at the University of Colorado, has shown that plants can grow at low atmospheric pressure. She suggests using plastic tents that maintain an air pressure 10 percent of that on Earth. Greenhouse air could be produced by

PHOTOS: NASA

manipulating the gas composition of martian air for optimal plant growth. Oxygen, the by-product of plant photosynthesis, could possibly be filtered from the greenhouses for use in human habitats.

Construction and manufacturing materials can also be made from martian soil. With the addition of water, soil can be formed into an adobelike brick for use in building houses. Dr. Benton Clark of Martin Marietta Co. has proposed processes to create a number of other building materials. For example, magnesium is a machinable metal that can be extracted from martian soil. Soil can be converted to glass by heating it to a high temperature. And a wide variety of cements can be easily manufactured using calcium, magnesium, and sulfur compounds.

Living quarters and seed-storage areas are best kept underground to shield people and seeds from radiation damage. Underground habitats also provide natural insulation against the temperature extremes of the martian environment. In addition, they could be easily sealed to enclose a breathable atmosphere.

Because of the low atmospheric pressure and temperature extremes on Mars, humans must wear pressurized and thermally insulated suits above ground. The suits must allow a range of at least 5 kilometers and be flexible enough to perform complex tasks. Life-support requirements would limit a manned rover, needed for exploring and expanding the base, to a range of about 50 kilometers.

The Mars base will ultimately be devoted to science after it is well established. Exploration and research will require remote-controlled vehicles able to travel at least 1,000 kilometers and return samples to the base. Such vehicles would not require the sophisticated artificial intelligence and mechanical design of a self-sufficient robotic rover, as the scientist operating the vehicle could decide how best to avoid an obstacle or which samples to retrieve. Several types of remote-controlled or robotic rover vehicles have already been proposed, including the Mars airplane—a glider designed by Victor Clarke of NASA's Jet Propulsion Laboratory and colleagues for the low atmospheric pressure of Mars. With a 21-meter wingspan, the glider can range up to 10,000 kilometers, carry and land instrument packages, collect samples, and conduct aerial surveys.

What Will It Cost?

Probably the most important factor in the decision to go to Mars is the mission's cost. The high cost of landing on the moon profoundly influenced the public's and politicians' attitude toward space exploration. Legislators and even NASA administrators often assume that new programs will cost much more than Apollo, disregarding the advances that have occurred since the Apollo era.

A manned mission to Mars first appears to be extremely ambitious and therefore prohibitively expensive. However, a detailed study by Humbold Mandell, Jr., a cost analyst at NASA's Johnson Space Center in Houston, indicates that, as mentioned, a single manned mission to Mars could be staged for one-half to one-third the cost of the Apollo program—or just over $20 billion compared with about $60 billion (in 1981 dollars). The total cost of a Mars landing would represent less than 1 percent of the estimated gross national product for 1990, while the total cost of Apollo was 2.8 percent of the average GNP during a single year during that time. Today's military budget annually is over 10 percent of the GNP.

In his estimate, Mandell assumes that the Mars mission would have a short, Apollo-style landing and use the space shuttle and today's space hardware. Costs would be lower than those of the Apollo program because much of the necessary technology already exists, and many development costs could be shared with other programs such as the space station.

A program that established a continued presence on the martian surface would cost more in the long-term. However, while some observers may suggest limiting the exploration of Mars to one or a few Apollo-style missions, the benefits of these missions diminish with their scope. Small-scale missions would fail to adequately study or develop the planet's economic and strategic potential. Considering the unique economic, social, and political implications of a martian settlement, cost should not be a deterrent.

Public interest in and support for exploring space are unquestionably reawakening. However, the motives behind this resurgence are very different from the international competition that first sent us to the moon. A program to settle Mars would provide the focus to meet the new challenge. □

TK!SO
EXPLA

TK!Solver does for equations what word processing did for words. The first thing you should know about the TK!Solver™ program is that it is not a spreadsheet. Instead, it does something completely unheard of (until now)—it turns your personal computer into a voracious equation processor.

The next thing you should know is that if the TK!Solver program can't make life with your personal computer easier (and pay for itself), even if you use it only 15 minutes a week, you are a very rare person.

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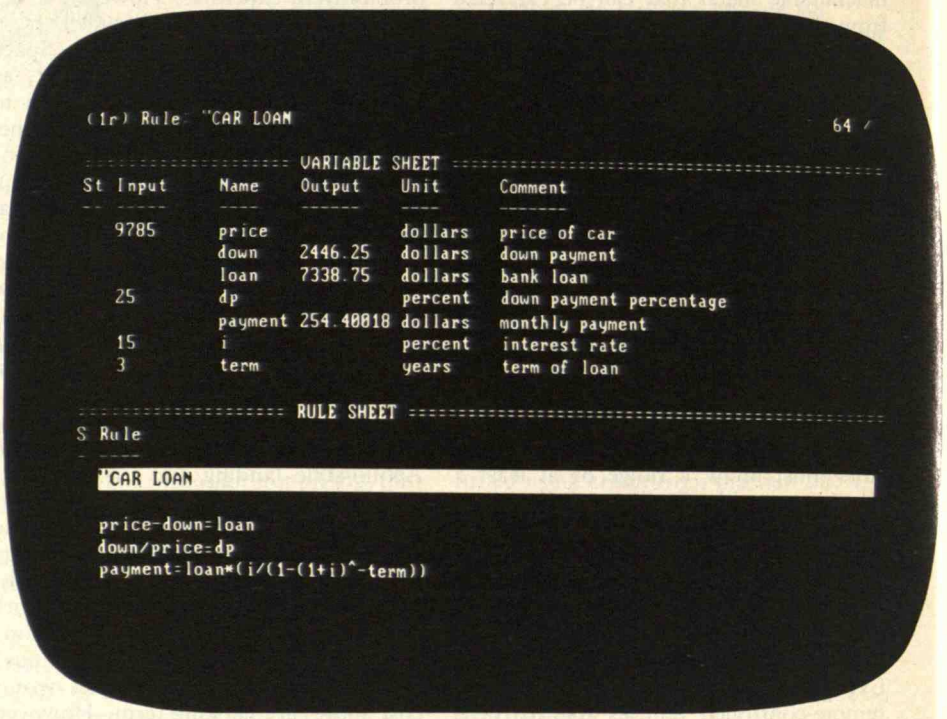
STEP 1. Formulate the necessary equations to solve your problem and enter them on the "Rule Sheet" simply by typing them in (see screen photo). For example: "price−down = loan."



STEP 2. Enter your known values the same way on the "Variable Sheet." For example: "9785" for price. You may also enter units and comments, if you want.*

STEP 3. Type the action command ("!" on your keyboard) to solve the problem.

STEP 4. TK!Solver displays the answer: the monthly payment is $254.40.

Backsolving, the heart of TK!Solver. Now that you've defined the problem and solved it, TK!Solver's unique backsolving ability also lets you think "backwards" to solve for any variable, regardless of its position in the equation. For example, if you can only afford a monthly payment of $200, you can re-solve the problem in terms of that constraint. The TK!Solver program will solve the problem, displaying your choice of a higher down payment, a longer loan term, or a lesser interest rate. This unique backsolving capability forms the basis of TK!Solver's remarkably flexible problem-solving ability.

*You can easily define appropriate unit conversions on the unit sheet at the same time.

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Also, as you can see from the example on the screen, TK!Solver deals not only with single variables, but with entire equations and sets of simultaneous equations. It also deals with much more complicated problems than this one. How complicated? That's up to you. What kinds of problems? That's up to you, too, but popular applications include finance, engineering, science, design, and education.

Other extremely useful and interesting things TK!Solver does. Aside from its basic problem-solving abilities, the TK!Solver program performs a number of pretty fancy tricks. Like: *Iterative Solving;* in which TK!Solver performs successive approximations of an answer when confronted with equations that cannot be solved directly, like $\exp(x) = 2 - x \cdot y$ and $\sin(x \cdot y) = 3 - x - y$. Like: *List Solving;* in which TK!Solver attacks complete lists of input values and solves them all, allowing you to examine numerous alternative solutions, and pick the one you like best. Like: *Tables and Graphs;* using the values you produced with the List Solver, the TK!Solver program will automatically produce tables and graphs of your data. You can look at your formatted output on the screen or send it to your printer with a single keystroke. And like: *Automatic Unit Conversion;* in which TK!Solver lets you formulate problems in one unit of measurement, and display answers in another. Very convenient what with all this talk about going metric.

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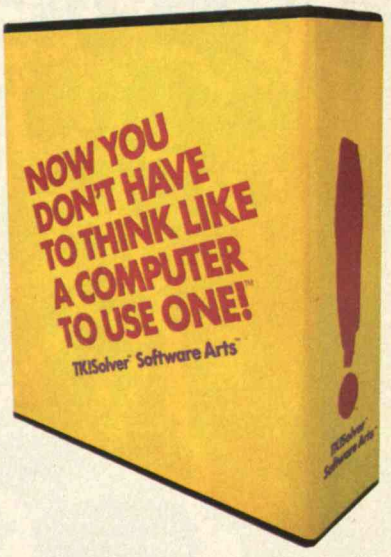

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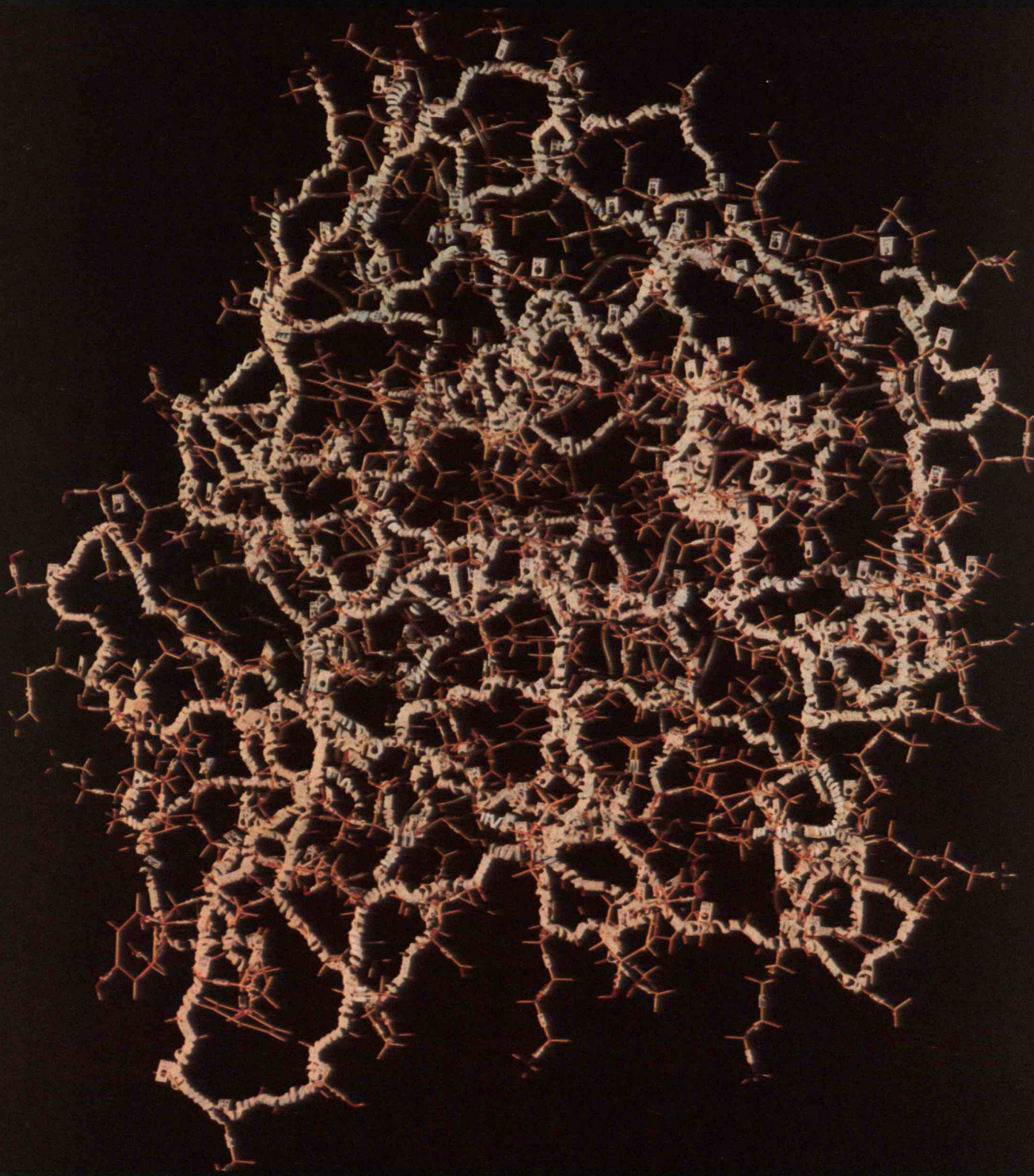


Enzymes: Nature's Chemical Machines

BY ALEXANDER M. KLIBANOV

Enzymes have promoted chemical reactions in living organisms for eons. Now they are being employed in making products from Coca Cola to detergents, and their future role in biotechnology looms large.

CATALYSTS, which enable chemical reactions to occur while remaining unaltered themselves, are employed in more than 70 percent of all industrial chemical processes. Enzymes are nature's catalysts. Nearly all chemical reactions in living organisms, whether bacteria, trees, or our own bodies, are promoted by enzymes. A few enzymes have also been used in industry—indeed, long before nonbiological catalysts were used. Rennet, an enzyme derived from the stomach of calves, is used to convert milk to cheese. Traditional fermentation processes employ microorganisms to do useful work through their enzymes. For example, in making beer, enzymes produced by yeast turn starch and sugars into alcohol. But until recently, the industrial role of enzymes was limited to these relatively simple processes, and the study of enzymes was almost exclusively academic.

Today, the situation is changing rapidly. The production of enzymes alone is a $400-million-a-year business. Biotechnologists are discovering powerful techniques to harness enzymes to transform one chemical into another, and they are beginning to achieve a broad range of practical results. Enzymes are used commercially to turn starch into sugar, provide cleansing agents in detergents, and simplify the manufacture of penicillin—to mention only a few applications. They promise to be of great use in producing chemicals, foods, drugs, and fuels; they can be used to break down industrial waste and analyze chemicals. Indeed, virtually any imaginable chemical process can theoretically be catalyzed by some enzyme (or several acting in a sequence). And like almost all the tools developed by nature through millions of years of evolution, enzymes are very efficient.

As enzymes—frequently improved by genetic engineering—replace conventional catalysts, the face of many chemical industries will change. Processes will become less energy-intensive, for they will not have to be carried out at the high temperatures required by most conventional catalysts. The processes can take place at the ambient temperatures at which nature's catalysts usually function. Capital investments in plants can be greatly reduced, because the expensive equipment able to withstand the usual high pressures, temperatures, and corrosive environments will no longer be needed. Reactions catalyzed by enzymes will take place under normal pressure and mild conditions—neither heavily acidic nor heavily alkaline. Today's complicated schemes for purifying reaction products and treating waste will be unnecessary, for enzymes are highly specific and produce only one product at a time.

However, these predictions require a significant qualification. Over the next 30 or 40 years enzymes are unlikely to be used on a large scale to produce inexpensive, bulk chemicals, because the existing petrochemical industry is able to make these products effectively from oil, natural gas, and coal. Often 60 to 80 percent of the cost of these bulk chemicals is due to the cost of the raw materials, and biomass feedstocks are not yet viable alternatives to fossil

What did the victim die of? This enzyme, Subtilisin Novo, catalyzes the breakdown of proteins in some of the victim's tissue, and any drugs are released. Medical detectives of an earlier day used chemical methods, which frequently altered drugs and introduced uncertainty.

PHOTOGRAPHS: NOVO LABORATORIES INC.

The objectives of nature, which created enzymes, differ fundamentally from those of the biotechnologist, who wants to harness them commercially.

fuels. Thus, a change in the manufacturing process would have little effect on the economics of the industry. Excellent nonbiological catalysts, such as metals, metallic oxides, and recent "coordination catalysts," have already been developed for synthesizing bulk chemicals, and considering the progress made over the past two decades, the opportunity for further improving these catalysts seems great. Also, enormous investments have been made in existing chemical plants, and since most now function well below capacity, the chances that manufacturers will make sizable investments in competing technologies are slim.

However, the story is quite different in the long run—especially in the specialty chemical, pharmaceutical, and food industries. Progress has already been made here, with the bulk of the commercial business so far in food processing. Papain, extracted from papaya fruits, is used in tenderizing meats. Tripsin, extracted from the pancreas of pigs, is used to convert porcine insulin into the slightly different human insulin molecule for treating diabetics. Several enzymes known as amylases, derived from barley and wheat germs, are used to turn cornstarch into sweet glucose, and an enzyme called glucose isomerase, produced by microbes, is used to transform this glucose into even sweeter fructose. The result is high-fructose corn syrup, used in soft drinks such as Coca-Cola and Pepsi-Cola.

Increasingly enzymes are produced from microbial sources rather than from plants and animals. Different companies frequently use different bacteria or other microbes to produce a given enzyme; each firm protects its particular strain by keeping it a trade secret or through a patent. Microbial enzymes are usually cheaper than those from plants and animals, and their supply is independent of weather, natural disasters, and political upheavals. (A severe shortage of papain a few years ago resulted from turmoil in Zaire, one of the largest producers of papaya.) Through genetic engineering, rennet for making cheese can already be produced on an experimental level from the bacterium *Escherichia coli* (usually abbreviated *E. coli*) or from yeast, as well as from calves' stomachs. Enzymes known as proteases, derived from a number of microorganisms, break the chemical bonds in proteins, and are used as cleaning agents in detergents. Genetic engineering should eventually enable all commercial enzymes to be produced from microbes.

Actual sales of enzymes—as distinct from products produced by enzymes—are dominated by three companies: Novo in Denmark, Gist-Brocades in Holland, and Miles Laboratories, based in the United States but owned by the German chemical giant Bayer. A number of large U.S. companies, including Staley, Clinton Corn, ADM, and Pfizer, make enzymes for their own use, chiefly for producing foods and pharmaceuticals. And many of the biotechnology companies formed in this country over the last decade, including Genex, Genencor (a joint venture of Corning Glass Works and Genentech), Bethesda Research Laboratories, and EnzoBiochem, either manufacture enzymes or intend to do so. These enzymes are mainly for use in the food and pharmaceutical industries; some are used in research for gene splicing.

Fortifying Natural Enzymes

Like nature, biotechnologists can frequently work with enzymes in a less than pure state. This is fortunate, because commercial enzyme preparations almost always contain other components such as proteins, carbohydrates, or metal salts. As long as such impurities do not interfere with the intended application of an enzyme, they do not create problems for the manufacturer. Indeed, it is sometimes even possible to use dead microbial cells containing enzymes as a catalyst, eliminating the purification process altogether. Although such cells cannot grow or multiply, their enzymes, as lifeless protein molecules, usually retain their catalytic potency for days. From a biotechnological standpoint, a dead cell can be considered a bag full of enzymes.

However, the objectives of nature, which created enzymes, and those of the biotechnologist, who wants to use enzymes commercially, are often entirely different. This is the source of all the major hurdles in the progress of enzyme technology. Enzymes are water-soluble, designed by nature to function in the aqueous solutions within cells. This property makes it difficult for biotechnologists to separate enzymes from the products they form so the enzymes can be reused. Nature needed flexible enzyme molecules, which exist for only several hours at ambient temperature and then are degraded by other enzymes within cells, called proteases. Biotechnologists, on the other hand, require robust enzyme molecules that will work for months and be resistant to relatively harsh conditions, including proteases, which may be

In large fermenters such as this one, which has a capacity of 100,000 liters, special strains of bacteria or other microorganisms are fed nutrients and produce enzymes.

found in the vats used for production.

Perhaps the most common cause of enzyme inactivation—that is, the loss of catalytic potency—is heat. In nature, most enzymes function at temperatures up to about 40° C, but when enzymes are used in industrial chemical reactors, the optimal temperature is usually between 37° C and 70° C. These elevated temperatures are necessary to increase the productivity of the chemical reactors and also to prevent contamination by microbes. Many enzymes that are very stable at low temperatures break down easily under such conditions.

What can be done about this? Conventionally, biotechnologists have sought enzymes from thermophilic microorganisms, which are accustomed to living at high temperatures. Some bacteria can grow and multiply—and hence their enzymes can function—at an incredible 250° C under 265 times atmospheric pressure. Finding the right heat-resistant enzyme requires a huge amount of work, however. One approach is to employ gene-splicing techniques to design microorganisms to produce enzymes that are sufficiently rugged and that will catalyze the desired reactions. This is a potentially rewarding, ambitious endeavor, but it will require a great deal of research before it can prove successful.

A practical strategy to alter many of the drawbacks of enzymes for manufacturing purposes is immobilization. In use for about 20 years, immobilization embraces several techniques to convert enzymes from a water-soluble, mobile state to a water-insoluble, immobile state. The enzymes are attached to supports so that they become more robust and can be separated from the solution for reuse. Consider an approach our laboratory has studied. As mentioned, an enzyme is a protein molecule, resembling a long looped string. Heat inactivates enzymes through partly unfolding their looped structures. But suppose an enzyme molecule is linked by several chemical bonds to a solid support. The support might be a polymer—a large number of linked organic molecules—such as polyamides used to manufacture synthetic fibers. We have found that the attached enzyme will unfold and be inactivated much less readily.

Unfolding is a common feature of several other ways in which enzymes are inactivated—for example, by extreme acidity or by organic (loosely speaking, oil-based) solvents. Thus, making enzymes more rigid by immobilizing them at many points on solid supports appears to stabilize them and make them more durable.

The numerous immobilization techniques that have been proposed all belong to one (or several) of the following five groups:

1. Attaching enzymes to solid supports by covalent chemical bonds (in which electrons are "shared" by the atoms bonded). Many supports have been used, including sand, stainless steel, cellulose, charcoal, and synthetic polymers. Porous supports are usually superior because they provide a higher surface area and hence a greater binding capacity. Several enzymes covalently attached to porous glass (glass formed into a microhoneycomb) or ceramic have been used commercially to convert glucose to fructose and for other processes.
2. Adhesion of a thin layer of enzyme molecules to

After being produced by microorganisms, enzymes (such as glucose isomerase, used to make sweetener from cornstarch) must be partially purified. The dead cells are often separated out by being spun in centrifuges such as those shown here.

solid supports, a process known as adsorption. The supports are provided by ion-exchangers—plastic-like resins that have the ability to exchange ions bound to their surface for ions dispersed in a solution. As the ion-exchanger releases its own ions, it takes up the many ions of an enzyme, thereby forming a tight bond. The appeal of this method is its simplicity: an enzyme solution is added to the support, the mixture is stirred for a few minutes, and the enzyme is adsorbed onto the support. Adsorbed enzymes have been used in the production of amino acids for foods and medicines, for example.

3. Entrapment of enzymes in polymeric gels. An enzyme is added to a solution of monomers, or small molecular units. Then either the temperature is changed or a gel-inducing chemical is added, linking the monomers into long polymers and forming a gel. The enzyme becomes trapped in the net of the gel. Polyacrylamide, a material similar to that used to make contact lenses, and carrageenan and alginate, obtained from seaweeds and often used to make ice cream, are used commercially for immobilization gels. One application of such gels is the immobilization of the enzyme aspartase, used to make a form of aspartic acid needed to produce the new low-calorie sweetener aspartame.

4. Cross-linking of enzymes. This process is similar to polymerizing enzyme molecules: the enzyme molecules are made to aggregate. The aggregates grow in size, eventually become insoluble in water, and fall out of the aqueous solution. The paste that is formed can be dried and ground to form enzyme beads. The enzyme glucose isomerase is sometimes immobilized this way in the production of high-fructose corn syrup.

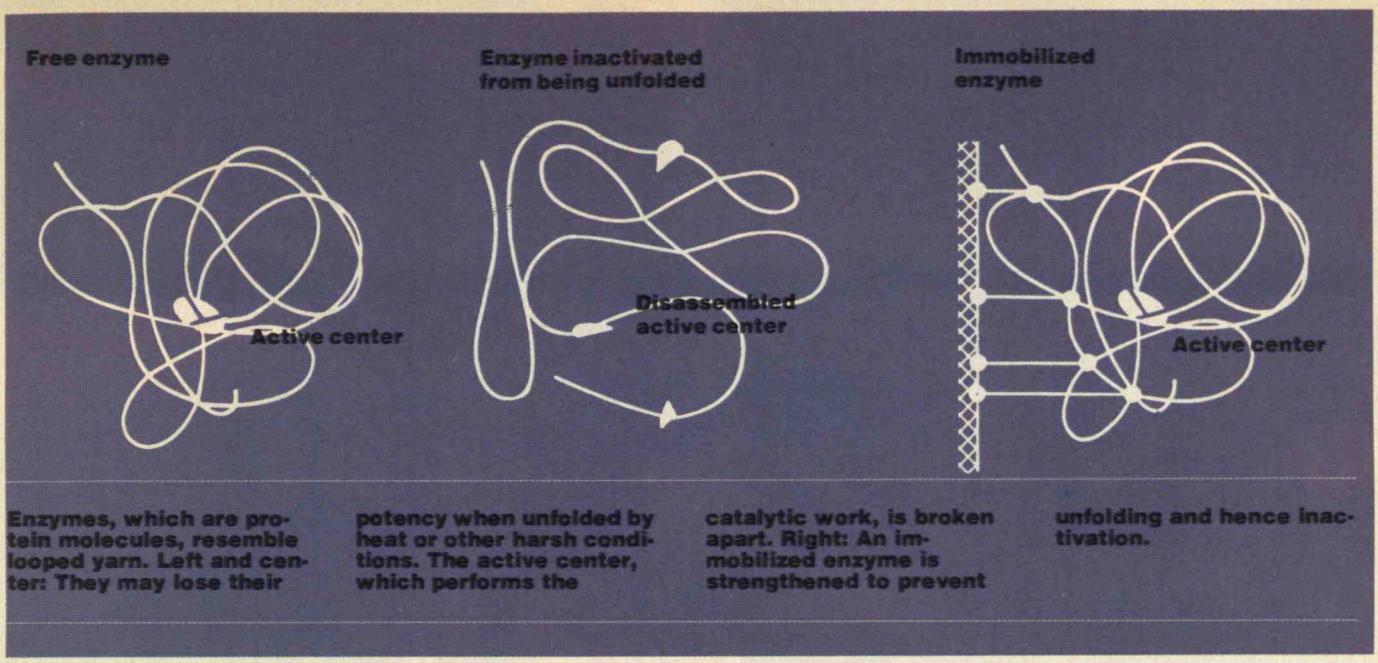
5. Encapsulation of enzymes. In this approach, enzymes are enveloped in various forms of membranes impermeable to the enzymes and other macromolecules, but permeable to low-molecular-weight chemicals. One example of this method is the use of encapsulated urease in artificial kidneys. In these devices, employed experimentally in hospitals as a possible replacement for standard dialysis machines, the urease enzyme breaks down the poisonous urea in the blood.

The advantage of the first and fourth methods is that they afford strong covalent bonds between the enzyme and the support. A disadvantage is that these methods are relatively laborious and expensive. Covalent binding can also render enzymes ineffective if they are attached through their active centers. However, this problem can be overcome if immobilization is carried out in the presence of substrates—chemicals that the enzymes act on—to protect the active center from being attached to the support. Adsorption and gel entrapment are very simple and efficient, but since they create no strong chemical bonds between the enzyme and the support, enzymes can often leak from the support. This drawback can be eliminated by using method four as well, cross-linking the adsorbed or entrapped enzymes. In general, there is no "best" way of immobilizing enzymes: the optimal method depends on the particular enzyme and its intended application.

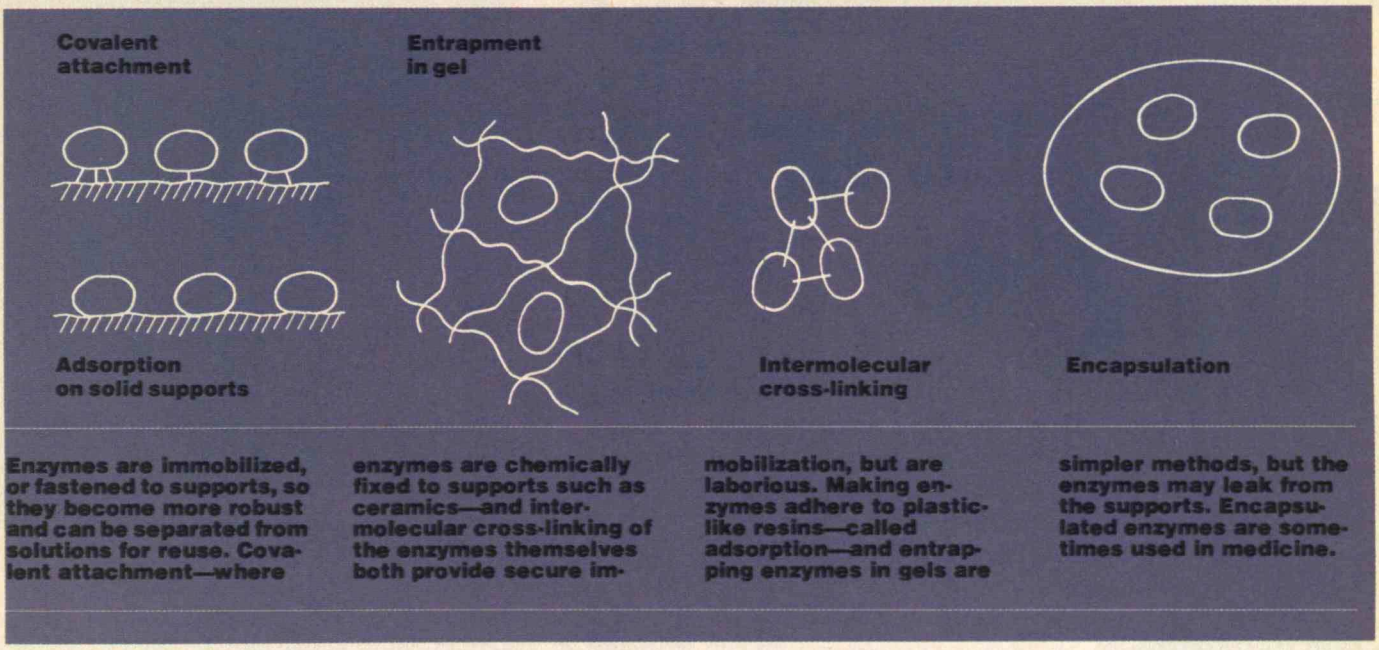
When properly carried out, immobilization almost always improves the technological properties of enzymes, allowing them to be used in conventional chemical reactors.

Enzyme Technology at Work

A few examples will suggest how immobilization techniques are now being used to produce speciality chemicals with enzymes.



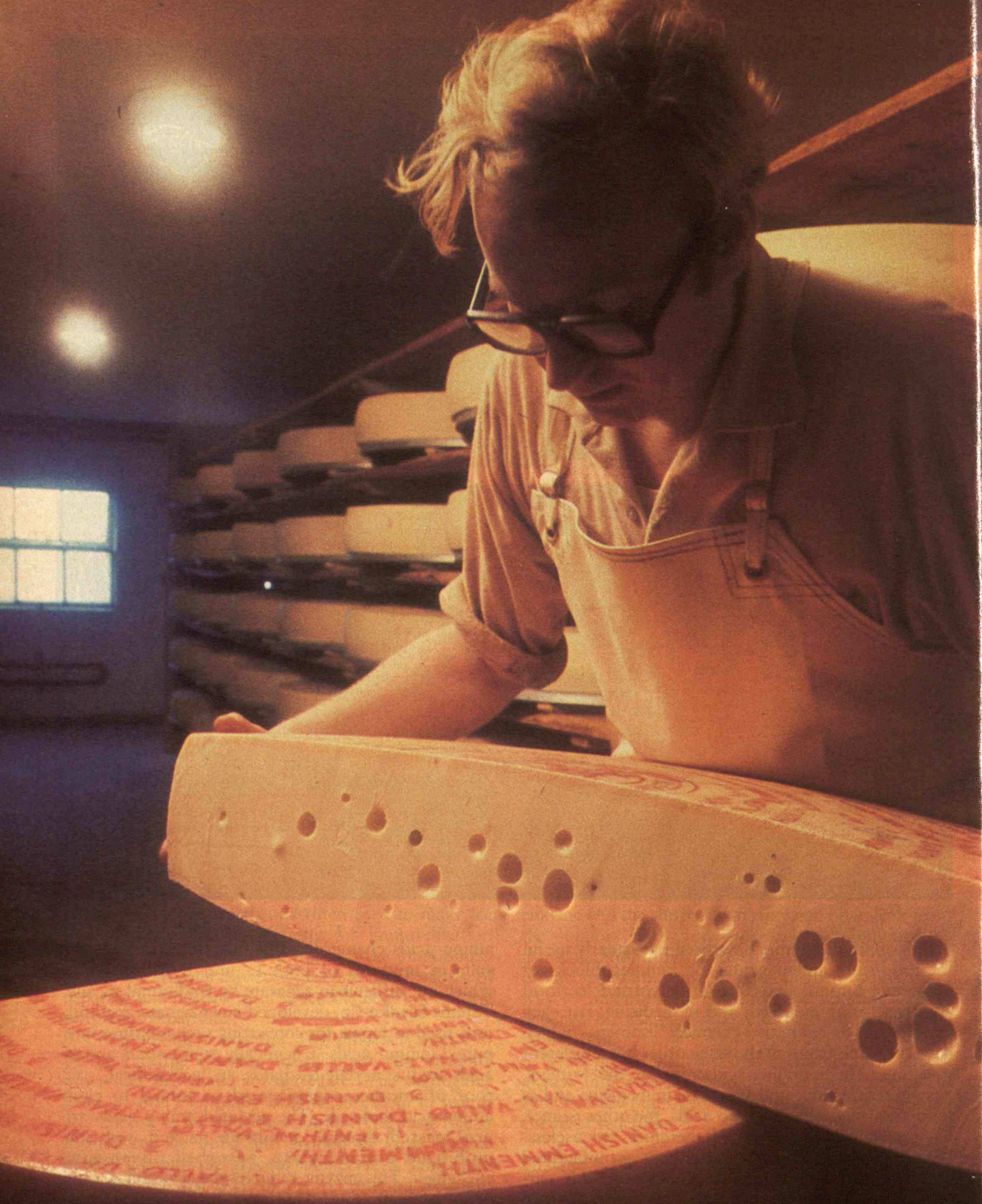
Enzymes, which are protein molecules, resemble looped yarn. Left and center: They may lose their potency when unfolded by heat or other harsh conditions. The active center, which performs the catalytic work, is broken apart. Right: An immobilized enzyme is strengthened to prevent unfolding and hence inactivation.



Enzymes are immobilized, or fastened to supports, so they become more robust and can be separated from solutions for reuse. Covalent attachment—where enzymes are chemically fixed to supports such as ceramics—and intermolecular cross-linking of the enzymes themselves both provide secure immobilization, but are laborious. Making enzymes adhere to plastic-like resins—called adsorption—and entrapping enzymes in gels are simpler methods, but the enzymes may leak from the supports. Encapsulated enzymes are sometimes used in medicine.

Immobilized enzymes have been particularly useful for producing amino acids, the building blocks of proteins. Amino acids are widely used as food additives, as animal feed, and in medicine. For each amino acid, there are two chemical "isomers," which have the same atoms in the same order but a different structure. The L-amino acids, one of the isomers, have nutritive value and are useful in medicine and as food additives. The D-amino acids, the other isomer, have no nutritive value and therefore are useless. L-amino acids have traditionally been manufactured by fermentation. Chemical feedstocks—mainly carbohydrates—are mixed with microorganisms (many types are used) to produce the L-amino acids.

It is simpler, faster, and cheaper to synthesize amino acids chemically. But this almost always results in mixtures of both L- and D-amino acids, which are difficult to separate by traditional means. Tanabe Seyaku Co. developed an enzymatic method, now used in Japan, for converting such mixtures into pure L-amino acids. Chemically synthesized amino acids are first acylated—that is, an "acyl radical," the root of another organic acid, is joined to each amino-acid molecule. The acylated amino acids are next passed through a column packed with immobilized aminoacylase, adsorbed on an ion-exchanger. This enzyme removes the acyl radical only from the L-amino acid so it can be isolated. The remaining acylated D-amino acid is heated to produce an equal mixture of L- and D-forms, and the separa-



At least 30 percent of the cheese marketed in the United States is made with a rennet enzyme produced by microorganisms rather than in a calf's stomach, as is traditional, according to Novo Laboratories, Inc.

Since in principle we can change genes any way we wish, we should be able to make cells that can produce specially tailored enzymes.

tion process is repeated. As always, it is possible to use a free, rather than an immobilized enzyme, but then it has to be replaced constantly. This means added costs, both for the enyzmes and for labor.

Another successful use of immobilized enzymes is in producing 6-aminopenicillanic acid (6-APA)—the core of semisynthetic penicillins—from penicillin G. Penicillin G is readily obtained by fermentation, a process carried out by many of the big pharmaceutical firms. The enzyme penicillin acylase, produced by *E. coli* and other microorganisms, and immobilized differently by different manufacturers, is used to transform penicillin G to 6-APA. Immobilized penicillin acylase is also employed industrially to acylate 6-APA to form novel penicillins to which the bacteria in the human body have not become adapted.

Immobilized enzymes hold particular promise for use in food processing. The competitors of enzymes, chemical catalysts, have not played and are not expected to play a significant role in food processing because of their "incompatibility" with food and for safety reasons. However, enzymes have been widely used in food technology, and immobilization technology is leading to many new applications.

The greatest commercial success so far has been in producing high-fructose corn syrup (HFCS). Various amylase enzymes, derived from barley and wheat germs, break corn starch down into glucose. Glucose isomerase, produced by microbes and immobilized by one of several possible methods, transforms the glucose into a mixture of about half fructose and half glucose. Because fructose is sweeter than glucose, HFCS is about as sweet as a sucrose, or common sugar, syrup (of the same solid content). As mentioned earlier, HFCS is used in soft drinks. In 1980 more than a billion kilograms of HFCS (based on dry weight) were produced in the United States, and by 1985 this figure is expected to double.

The history of producing HFCS catalyzed by immobilized glucose isomerase illustrates the role of economics in enzyme technology. Although the technology was ready by 1970, the price of raw sugar was then less than 10 cents a pound. Since HFCS could not be produced much cheaper than that, the process was not commercialized. In November 1974, when the price of raw sugar soared to 50 cents a pound, the glucose isomerase process suddenly became highly profitable. Capital was invested in the process, and the technical demands posed by large-scale production were solved. Thus, even when the price of sugar plummeted to less than 10 cents a pound again at the end of 1976, industrial HFCS production survived. In fact, it even expanded, capturing much of the market for liquid sweetener previously held by sucrose. This enzymatic process makes it possible to replace imported sugar with an equivalent sweetner made from surplus U.S. corn.

Another process, commercialized about a year ago, converts the lactose in whey (a by-product of cheese manufacturing) into a mixture of the sweet sugars glucose and galactose by using a microbially produced enzyme lactase that is covalently attached to porous glass beads. The glucose-galactose syrup produced is beginning to be used as a protein-rich sweetener for baked goods, ice creams, and jams.

Many enzymes exhibit unique specificity, reacting with only one substrate out of many. This virtue (absent in almost all chemical catalysts) is especially valuable for measuring the concentration of a particular compound in a solution containing many compounds. The potential of immobilized biocatalysts in chemical and clinical analyses can be best illustrated by "enzyme electrode" technology.

Identifying the concentration of particular compounds in complex fluids, such as blood or industrial waste, is a difficult task that usually requires many time-consuming operations. It would be very helpful if it were possible to simply place an electrode in a sample and read the concentration of the compound of interest. Electrodes now available can give the concentrations of a narrow range of chemical species—H^+, O_2, NH_4^+, CO_2, and a few others—but not for more complex molecules such as amino acids or sugars.

A revolutionary idea is to couple such an electrode with an immobilized enzyme. An electrode is wrapped with a polymeric film containing an enzyme, which converts the compound of interest to one that can be directly measured by the electrode. For example, the enzyme L-amino acid oxidase produces one ammonium ion (NH_4^+) per molecule of L-amino acid. Coupling this enzyme with an NH_4^+-sensitive electrode creates an "enzyme electrode" that can directly identify L-amino acids. This principle has general applicability. It has already been used to assay a wide variety of clinically, environmentally, or otherwise important compounds, including individual amino acids, glucose and other sugars, phosphates, urea, cholesterol, and penicillin. Yellow Springs Instruments, in Yellow Springs, Ohio, pioneered this

method on a commercial scale. Theoretically, almost any compound can be assayed by an enzyme electrode composed of a suitable electrochemical probe and an immobilized enzyme or a combination of enzymes acting in sequence.

Most medical uses of enzymes focus on removing undesirable compounds from the blood. For instance, microencapsulated asparginase produced by microbes has been injected in patients on an experimental basis and used effectively to treat some kinds of leukemia. This treatment is based on the ability of the enzyme to decompose L-asparagine, an amino acid required by tumor cells to a much greater extent than by normal cells.

Another promising use for immobilized enzymes was developed by Professor Robert S. Langer at M.I.T. Blood of patients that is to be purified in an artificial kidney or in a pump-oxygenator usually has heparin added to keep it from clotting in the mechanical device. Before the blood reenters the body, the heparin must be removed to avoid bleeding complications. This problem was solved by using a blood filter containing the immobilized enzyme heparinase, which degrades 99 percent of heparin's anticoagulant activity within minutes.

Enzymes from Gene-Splicing

One of the most potentially rewarding trends in biotechnology is the development of gene-splicing techniques for engineering microorganisms capable of producing new enzymes. Specially designed enzymes may be more resistant to heat and harsh environments than natural enzymes, and redesigned enzymes may be able to catalyze the production of products for which there are no known natural enzymes.

As proteins, enzymes are composed of long chains of some 20 different amino acids. The properties of enzymes are determined by the order in which these amino acids appear. This linear sequence is called the primary structure. The information needed to form an enzyme (or any protein) with a given primary structure is contained in the genes of the cell—molecules of DNA (deoxyribonucleic acid). Living cells contain precise and efficient machinery to transform the information in the DNA into numerous copies of specific proteins, including enzymes.

DNA is a chain of thousands of individual nucleotide units. There are four types of nucleotides: cytidine (C), guanosine (G), adenosine (A), and thymidine (T). The sequence of these four units in the DNA chain codes for the sequence of amino acids in proteins. A triplet of nucleotides codes for one amino acid. For example, the triplet CCC codes for proline; GCC codes for alanine; CAC codes for histidine. A segment of the long DNA chain that codes for one entire protein is called a gene.

The essential part of recombinant-DNA technology, or genetic engineering, is the ability to change the nucleotide structure of a gene in a controlled way. This can be done either by changing the DNA molecule or by inserting new, chemically synthesized, genes into the DNA strand. Cells with such altered DNA molecules will then synthesize proteins, including enzymes, with altered properties.

Since in principle we can change the genes any way we wish, we should be able to do the same with the properties of the resultant enzymes. Indeed, the only thing nature does when it switches from an enzyme that breaks down starches to one that breaks down penicillin, or from an unstable to a stable enzyme, or from an enzyme with low activity to a highly active one, is to reshuffle the nucleotide sequence of a given gene. This in turn reshuffles the primary structure of the enzyme.

How can genetic engineering help enzyme technology? As mentioned, some industrial enzymes are now produced from animal and plant sources. To obtain a more abundant supply of such enzymes, it would be helpful to transfer their genes into enzyme-producing microorganisms. This approach has already been successfully explored with the gene for calf rennet, which has been inserted into *E. coli.* Soon it will be possible to produce calf rennet by fermentation; that is, by growing a colony of *E. coli* in a mixture of glucose, proteins, salts, and essential minerals. Microorganisms that make enzymes can become extremely productive, since numerous identical copies of the gene that codes for the enzyme can be introduced into the DNA. Rennet, for example, can constitute more than 20 percent of all the protein produced by a recombinant bacterium.

Through genetic engineering, enzymes used in medicine may be produced far more cheaply than they are now. Today, these enzymes usually have to be of human origin to avoid being rejected by the immune system. For instance, the enzyme urokinase is used to treat victims of pulmonary embolism, heart attacks caused by blood clots, a disease suffered by

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To M.I.T. Students:

As a faculty member as well as alumnus, I take particular delight in welcoming you as complimentary subscribers to the student edition of the Alumni Association's magazine, TECHNOLOGY REVIEW. At Commencement Exercises when you receive your M.I.T. diploma you will officially become alumni, but I want you to begin your acquaintance with the Alumni Association, as prospective members, as you enter the final stages of your education here.

TECHNOLOGY REVIEW has a two-fold assignment: to provide for its subscribers a sense of current issues and developments in technology and related fields, and to provide for all alumni continuing contact with the Institute and among themselves. TECHNOLOGY REVIEW is published eight times a year for some 35,000 alumni who continue their support of the Institute and over 40,000 subscribers who pay to receive it as a professional publication. The student edition will be sent to you without charge five times during the current academic year.

Nearly 75,000 former students of M.I.T. are carried on the rolls of the Alumni Association. When you graduate from the Institute, the Association will be the means for your continuing involvement with M.I.T. and contact with your classmates--as it has been for me continuously for over thirty years as employee and faculty member. Through the Association, M.I.T. alumni are active in over 100 M.I.T. clubs throughout the world, as workers for the annual Alumni Fund, and as Educational Counselors interviewing prospective M.I.T. students. We also serve on numerous committees, trusts, and boards, and on the M.I.T. Corporation, in support of the Institute and our fellow alumni. We sponsor and participate in a number of conferences and special events both on and off the campus.

We hope that as a student you will join us in some of these activities, many of which are announced in the pages of TECHNOLOGY REVIEW and TECH TALK. I know from my travels and contacts that alumni enjoy meeting students--not only because they are anxious to keep in touch with M.I.T. but because we are all sincerely interested in your well-being and your understanding of the professions which you are likely to serve after graduation. During the year you may have opportunities to visit with alumni to share your experiences at the Institute and discuss your future plans and interests; we hope you'll find these occasions interesting and even helpful. Please come to the Alumni Center (Room 10-110) to learn more about the Association and to arrange to join in the alumni activities.

I trust the TECHNOLOGY REVIEW will serve you as well as it has me and that the habit of reading it will lead to a sustained relationship with M.I.T. after graduation. As I commence my term as the first "resident" President of the Association since 1928, I anticipate with pleasure the opportunity to greet each of you personally at one of the many occasions when alumni and students will come together during this academic year.

Robert W. Mann, '50 President

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Why do astronauts experience motion sickness in space? The theory is that these symptoms arise when the brain receives contradictory information about the body's orientation or movements.

Consider the situation in which an astronaut is stationary with respect to the capsule but the capsule is moving. The astronaut's visual and tactile signals tell the brain that he/she is not moving. But the otolith, a gravity-detecting liquid-filled organ within the inner ear, reports to the brain that he/she is traveling at a high velocity. These conflicting signals, it is hypothesized, lead to motion sickness.

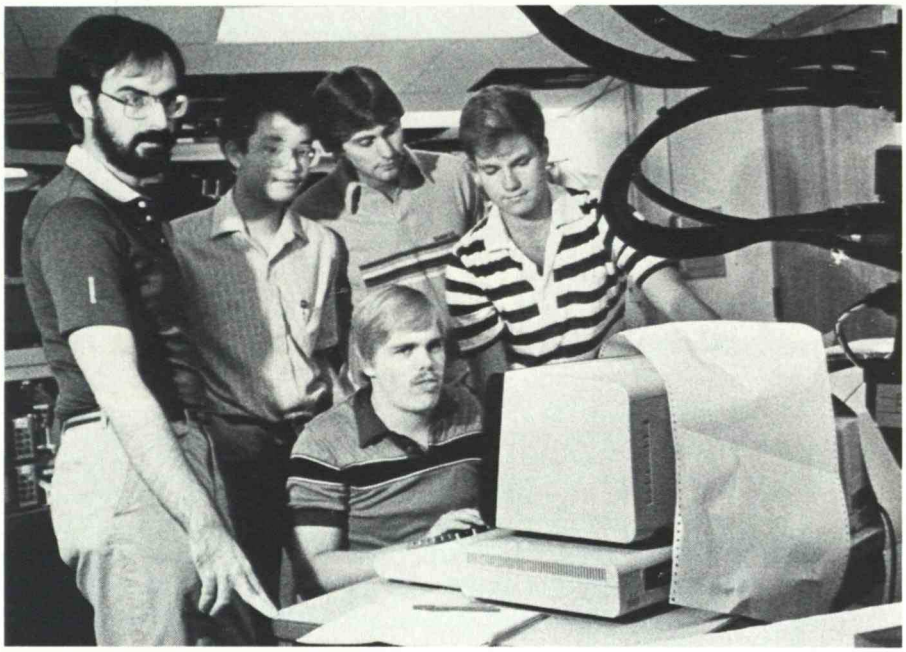
Astronauts typically suffer from motion sickness for the first three to seven days in orbit. Members of the Man-Vehicle Laboratory at M.I.T. theorize that astronauts make their adaptations to the zero-gravity environment by learning to ignore the signals from the otolith, thus increasing their dependence on visual and tactile cues. But experimental verification of this theory is lacking; simulation experiments on earth turn out to be poor indicators of who will suffer motion sickness in space, and in any case no universally effective remedy for this disorder is available.

To increase understanding of motion sickness, a coordinated set of experiments on how the human body functions in space has been designed jointly by researchers at M.I.T., McGill University, and the Defense and Civil Institute of Environmental Medicine (Toronto, Canada).

Investigators are focussing on three main topics: space motion sickness, sensory adaptation to weightlessness (with particular emphasis on the otolith), and the post-flight persistence of such adaptations. One element of this program, assigned to M.I.T., is a project to investigate changes in otolith function in Spacelab crew members, the first phase of which was scheduled for a September Space Shuttle flight that is now postponed until late November and may not lift off until next year.

At the M-V Laboratory last April the astronauts rode an accelerating "sled" while deprived of all senses that would aid motion perception. Teams of undergraduates will repeat these tests after the flight, measuring the astronauts' eye movements, otolith activity, and ability to sense the direction and speed of their motion. The differences between preflight and post-flight performance were expected to help in understanding a basic physiological question: How does the otolith sense linear acceleration and detect changes in gravity?

Undergraduates had crucial roles in this project. In addition to the students involved in each of the four test programs, three undergraduates worked on the sled, one in charge of each area—mechanical, electronic, and computer. The students' propose that their new understanding of themselves as scientists-to-be may be as important as their answers to the questions about the otolith.—*Lisa Maiocco,* '86 □



Ten students from as many universities—not including M.I.T.—spent five weeks at the Institute last summer learning about robotics. The idea, according to Professor Tomas Lozano-Perez (left), was to stimulate students at other institutions and share with them M.I.T. expertise in the field.

Thurow on Education

The United States is at a disadvantage in today's competitive world because its educational system is weak, says Professor Lester D. Thurow, economist at M.I.T.'s Sloan School of Management. "You can't build a high-quality product with low-quality components," he told Diana ben-Aaron of M.I.T.'s student newspaper, "and one of the components going into the American economy is the quality of our education."

Thurow's prescription for better education:

□ Increase the length of the school year. "The whole world goes to school longer than we do"—240 days in Japan, 220 days in Germany compared with 180 days in the United States.

□ Enforce higher standards. Most other nations have national exams for high-school graduation. "You can't run a school system without quality control," he said.

□ Improve the teaching. In general, said Thurow, the achievement scores of people who go to U.S. schools of education are "dismal." To attract better people and claim higher performance, the United States will have to pay its teachers better.

□ Make quality education a higher priority among U.S. parents. Thurow thinks it's now "the last thing in the world many parents want. . . . Forcing your kids to do homework is a lot more work that letting them watch TV, so a lot of parents want babysitting. . . . Education is a pain in the neck." □

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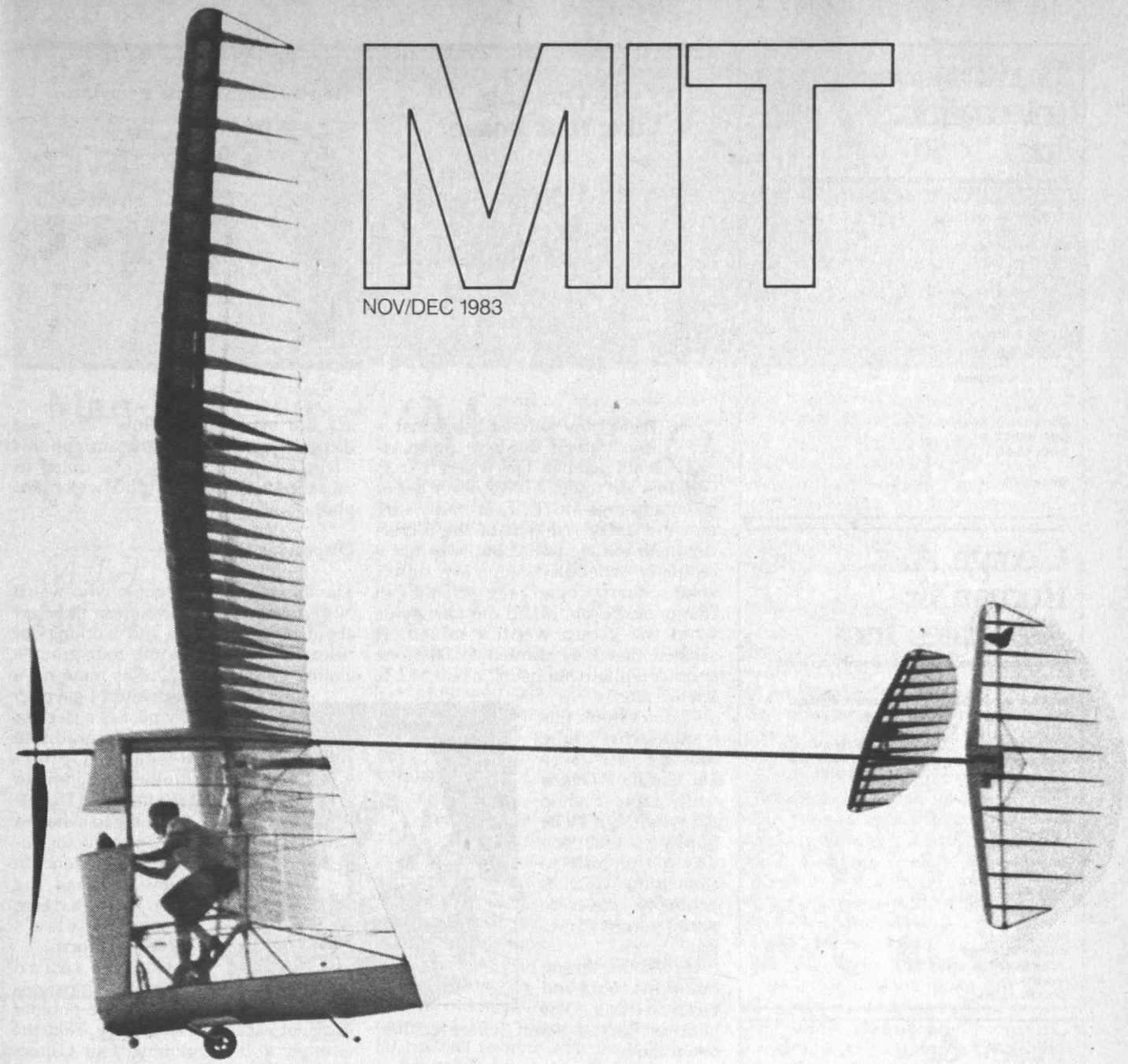


COVER: "MONARCH" IN FLIGHT, © 1983 STEVE FINBERG, '78

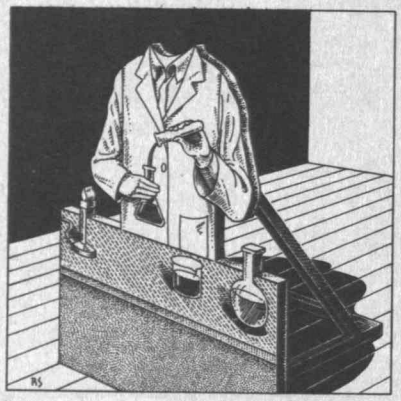
Is Our Lab Like Your Image?

Student View/Diana ben-Aaron

Diana ben-Aaron, '85, is majoring in humanities and materials science. This is one of her series of essays on "Materials Scientists at Work" awarded second prize in the M.I.T. Writing Program's 1983 DeWitt Wallace Prize Competition in Science Writing for the Public.

One day the summer before last, a tour passed through the materials science lab where I was working. Although I have never led or taken a tour of M.I.T., I was fairly sure that the dingy hangout of the Superconducting Materials Group was not a regularly scheduled stop. My supervisor, Stuart Cogan, the scientist in charge of the lab, asked the tour guide what the group wanted to see. It seemed that they wanted to take one another's photographs in "a real M.I.T. science lab."

"I don't think this is quite what you're looking for," said Dr. Cogan. "This is really more a shop than a lab. But I'll be happy to take you down the hall to something which is probably closer to what you want to see."



He led the throng out of the room and returned a few minutes later. I asked where he had taken them.

"Oh, I left them at John Elliot's lab." What, I asked, was the attraction at Elliot's lab?

"Nothing, really—just lots of shiny glassware and bubbling cauldrons. It *looks* like a lab."

With that, we returned to the task at hand. I do not remember what it was, but the television cameras were not queueing up to watch us. In fact, the mass media would not be interested in our work under any circumstances; we are not exploring a "hot" area, we haven't turned up many monopoles lately, we don't expect to be called to Stockholm some day, and we're not photogenic.

I have yet to see anyone wear a lab coat in our lab. If we did, it would be for the same reason we use gloves and I sometimes wear an apron: self-defense—not show.

Disproving the Image

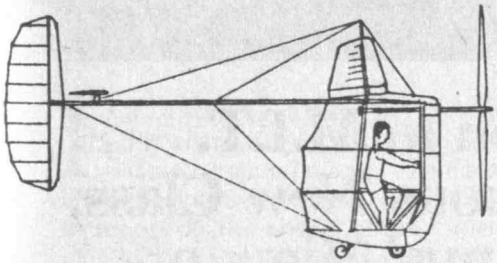
The majority of the people who watch NOVA will never have their illusions about the appearance and workings of research shattered as the tour group's almost were that day, or as mine have been since I gave up my post as a clerk in the Undergraduate Research Opportunities Program to join the lab. (The office job had whetted my appetite for research and science in general; I had the fun of reading everyone else's glowing reports.)

What I found disproved most aspects of the popular image of a scientific laboratory. Take the example at the beginning. Our visitors were presumed to be looking for a scaled-up high-school chemistry bench with banks of microscopes, Bunsen burners, centrifuges, Geiger counters, and custom-blown Pyrex. Some scenes of investigation do look like this. Some look like high school auto-mechanics-and-manual-training shops, some like museums, some like factories, some like zoos, some like libraries, some like power plants, some like high-tech computer corporations, and some like dumps. (I do not exclude ours from this category, but a better example is the National Magnet Lab. "When you're finished with a piece of wire, you throw it into the garbage," says one graduate student. "At the National Magnet Lab, the garbage can is the floor.")

continued on page A27

Man-Powered Quest Renewed by "Monarch"

M.I.T.'s Fourth Human-Powered Plane Is the Best Yet



"Monarch," a new M.I.T.-built entry into the Royal Aeronautical Society's human-powered aircraft competitions—began flights late last summer with no fanfare at all. The goal is to twice fly (with stored energy supplementing the pilot's pedalling) a 1,500-foot oval course—once in less than 3 minutes, about 20 m.p.h.—for a $33,000 prize. As the *Review* went to press, John S. Langford, '79, a graduate student in aero and astro, told *The Tech* that "It looks good, and we're hopeful—but not confident." (Photo: © 1983 Steven Finberg)

"Monarch," a new human-powered monoplane produced by the fertile minds of students, staff, and faculty in the Department of Aeronautics and Astronautics, made its maiden flight late in the summer with no fanfare at all. Suddenly it was a top contender for a new $33,000 prize offered by the Royal Aeronautical Society.

To win the prize, "Monarch" must make two flights—one in each direction—along an oval course that incorporates the three points of a narrow-based triangle—total length 1,500 meters. One of the two flights must be made in less than 3 minutes—about 20 miles an hour—and the rules permit the use of stored energy to aid propulsion.

So the challenge is to combine energy storage and release, propeller, landing gear, bicycle drive, wings, and tail into something that will fly, carrying its own weight and that of a pilot, around a circular course that is more than one-tenth of a mile long.

As this issue of the *Review* went to press, "Monarch" was disassembled and in storage, having been slightly damaged in a landing during test. Flights will resume with good weather in the spring.

"Monarch" was designed by John S. Langford, '79, Mark Drela, '82, and Scott Clifton, graduate students in aero and astro; Juan Cruz, '84, a senior in the department, and Stephen L. Finberg, '77, of Draper Laboratory. Several had been involved in Chrysalis, the department's previous human-powered project. Design work on "Monarch" began last May, and during the summer the project claimed 4,700 man-hours of effort in construction.

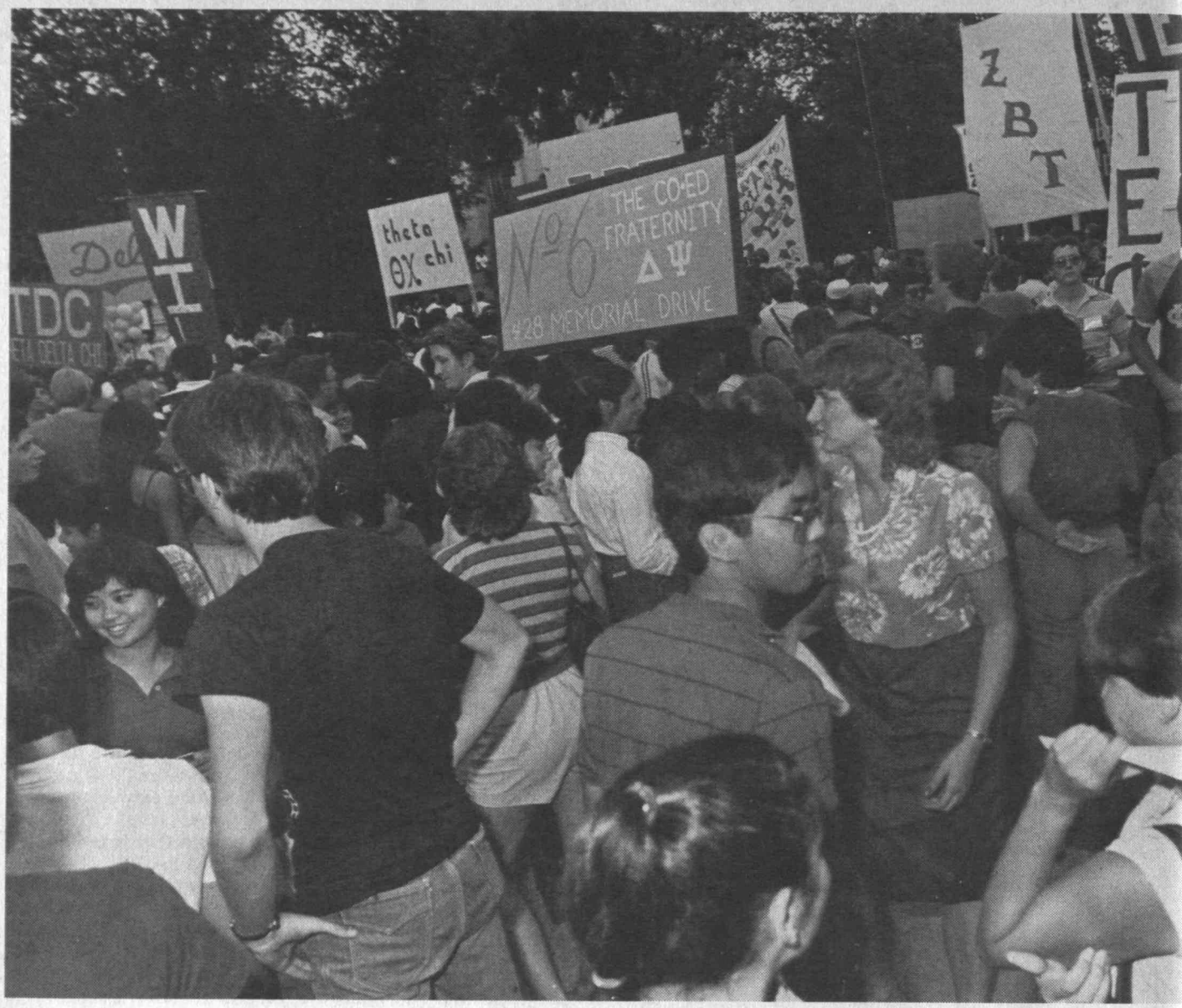
It continued to claim a heavy load of time from its many participants throughout the test period. Roll-out during the fall was between 4 and 5 a.m., with test flights beginning at 6 a.m. to take advantage of the still, cool air of dawn. The "Monarch" crew was usually back on the campus by 10 a.m., ready for the rest of the day's work.

All that effort has been contributed at no cost to the project. Materials—aluminum, graphite, Kevlar, Mylar, and plywood, and others—and equipment have cost about $3,700, according to Langford, 60 percent of which has been provided by the department, the rest from crew members' pockets.

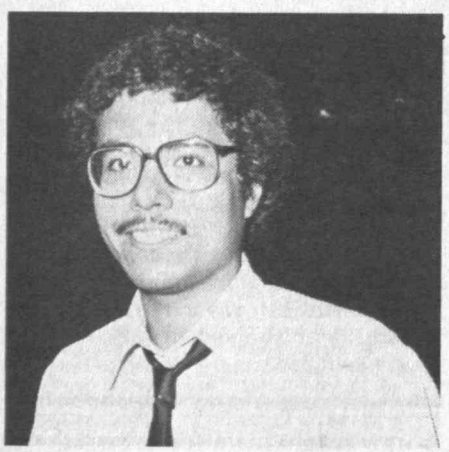
Pumping Up the Battery

The rules say that the auxiliary power source can be fed energy by the pilot for 10 minutes before every flight. Then that power can supplement the pilot's pedalling in flight to make the plane go fast enough to meet the 20-m.p.h. requirement. The entire crew agreed that "Monarch" should have a flywheel. "But we also agreed that it would take too long to design a good flywheel system," Langford says. So with the tight deadlines the team decided on a battery-driven electric motor, with the pilot using the motor as a generator to charge the battery for ten minutes before every flight. The final design used a 1-hp model-airplane motor driven by 24 "C" batteries (total weight: 2 pounds). The whole electric popuslion system weighed in at 6-7 pounds. (Shortly after David Arnold of the Boston *Globe* published an account of the "Monarch" project, he received a call from California probing for "some very technical information." Was it from Paul MacCready, designer of "Gossamer Condor" and "Gossamer Albatross," who is supposed to now be building a "Gossamer Swift"? It was indeed, and MacCready later showed up at M.I.T. to give a seminar.)

A new mechanism for camaraderie and one-on-one interaction between students and faculty. Project chief John S. Langford, '79: "It looks good, and we're hopeful—but not confident."

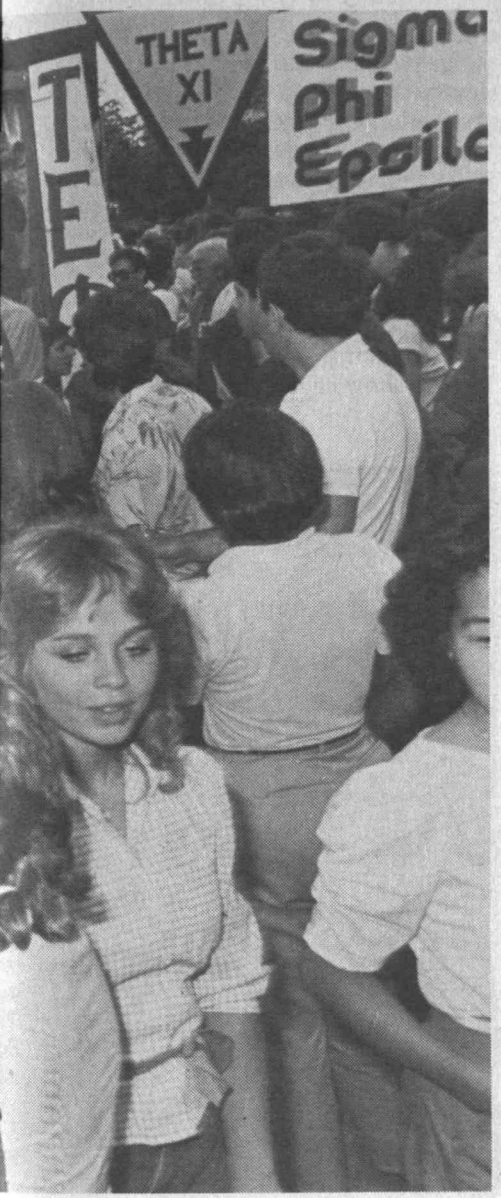


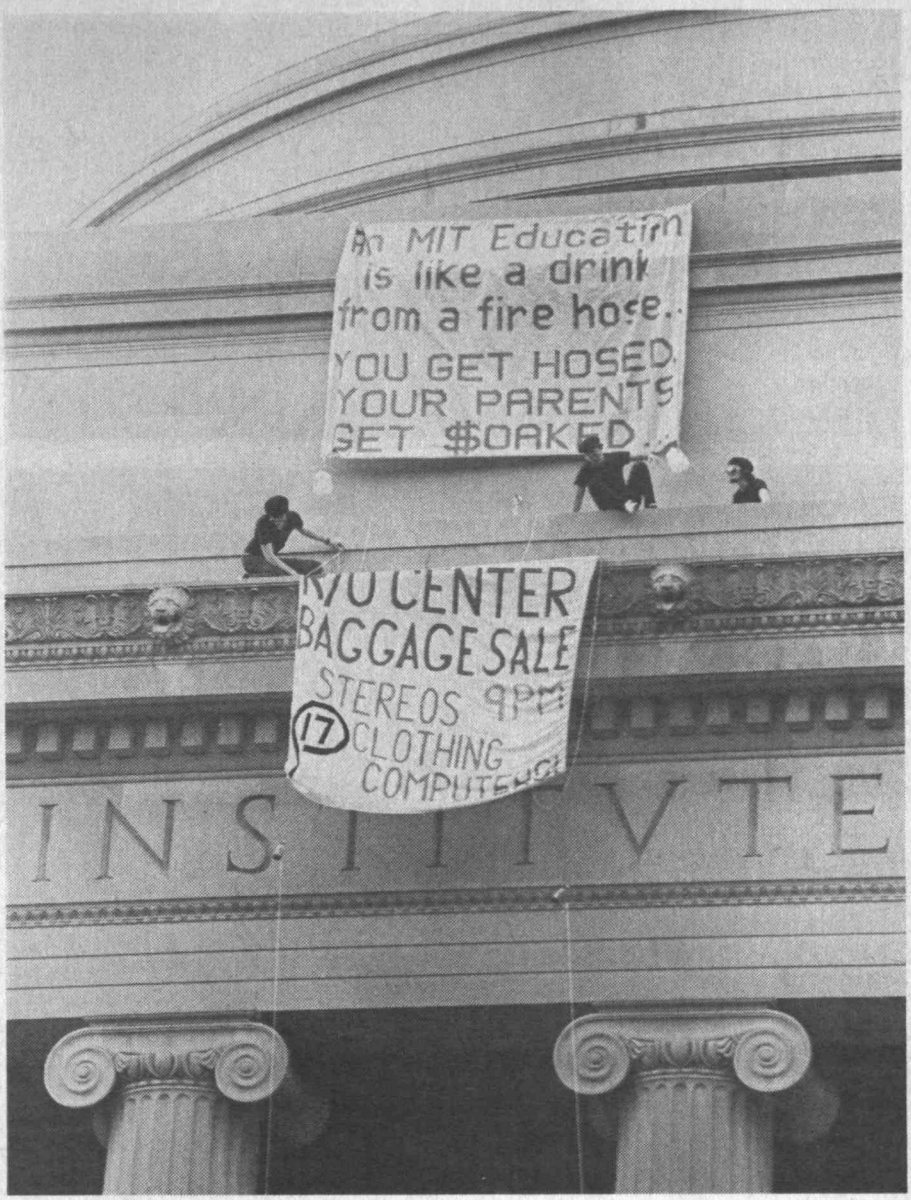
Initiation to M.I.T. for a Gregarious New Class: An Alumnus' View of R/O Week



Peter Mui, '82, studied computer science, wrote an undergraduate thesis in physics, and currently works with sonar with "Doc" Edgerton.

Text, Photographs and Design by Peter Mui, '82





DONALD M. DAVIDOFF, '86

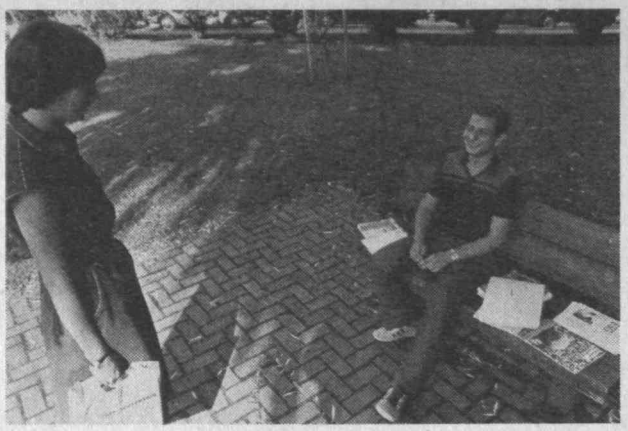
Five years after my own Freshman Week—a whole undergraduate career later—*Technology Review* asked me to report on the arrival of the Class of 1987. It seemed to make good sense to send a recent graduate back to cover the first days of the freshmen on campus: because of my age, I could blend in well at many of their activities and even pose successfully as one of the new arrivals if the situation warranted. As it turned out, I really made no attempt to conceal what I was, and, because I was very much a fixture during the week, many of the freshmen used me as a sounding board for their queries. While I was trying to get their impressions of M.I.T., they were trying to get mine.

Be forewarned, then, that this is not a dispassionate, third-person report. I helped shape many conversations by being the freshman or upperclassman of the interaction. I excused myself prematurely from the Writing Requirement exam, which I had originally intended to take, because I felt I might affect the performances of the freshmen at my table. Likewise, when asked questions of a sensitive nature, I diplomatically sidestepped direct answers—there were many things I would've liked to have told the freshmen, but I didn't feel I had the right to deprive them of learning the answers for themselves.

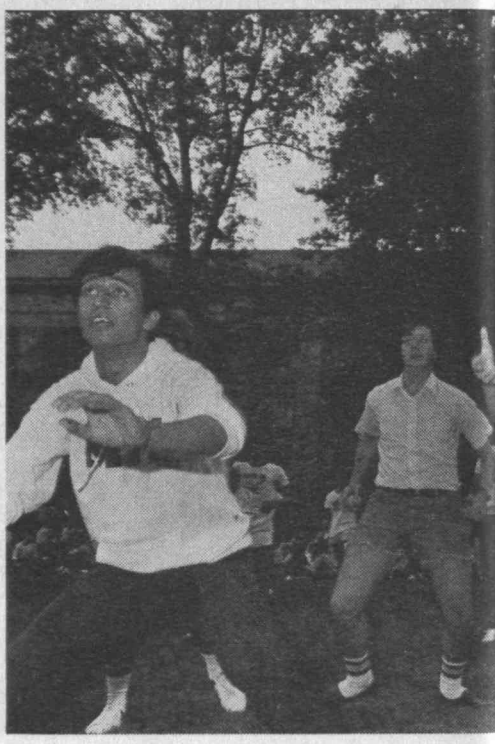
Just before the freshmen arrived for Residence and Orientation (R/O) Week, I went to see Peter Richardson, director of admissions, for a demographic breakdown of the class and a list of its notable members. His reply was to tell me that—while there were champion athletes, math and science honoraries, and junior statesmen in the class—there was in fact "a story on every freshman." After having spoken with what must have been a third of the entering class, I couldn't agree more. R/O Week became for me not only a voyage into my own past, allowing me one last look on my undergraduate years before moving on, but—more important—a glimpse of M.I.T.'s kaleidoscopic future.

Thursday, September 1

Each year, the transition from summer to fall is marked by the nip in the air, the turning of the leaves,



Aleks Gollu was sifting through the numerous information pamphlets, trying to organize them in some logical fashion on the bench, making a physical analogue of the process he was going through in his mind. A freshman from Istanbul, Aleks had questions about his English fluency, which appeared excellent but for a slight German tinge. He then explained he had gone to a German secondary school in Turkey and was considering living in German house, where he knew an



and the arrival of the U-haul trailers on the streets of Cambridge and Boston as the students return for the fall term. For 1,070 M.I.T. admits in the Class of 1987, it is the first time they are making this pilgrimage, and waiting to greet them are the perennial observers of this event; members of the Faculty, the Dean's Office, and a small army of upperclassmen who have voluntarily cut their summer a few weeks short in order to provide a helping hand and a smile.

Peter Richardson finally has a chance to see the people he knows so well yet has never met. The whole Institute takes on new life as these people walk through the corridors, clutching their information packets and catalogs, listening carefully to the sounds flowing past them, looking intently at the bulletin boards and into the open offices, testing the space. To Richardson and his staff, the hallway in front of the Admissions Office is suddenly different, and they can hardly go about their daily business because of the temptation to watch the passing parade. As Professor Jay Keyser noted at the end of the week, it's a time of special serenity for Richardson: he knows that not a single one of the new arrivals or their parents wants to question his judgment.

"Where?" was the question of the day at the Residence/Orientation (R/O) Center. Arriving freshmen went through a cafeteria-style line; they were relieved of their excess baggage, given a packet containing various pamphlets and tickets, handed a course catalog, and told how to find their temporary housing assignments.

Between the R/O Center and the dorms were more upperclassman to help carry luggage and insure that no one got lost. Karen Turato, shift captain at the R/O center, noted the special atmosphere of R/O Week as a reason why so many students return to help. "Upperclassmen get incredibly friendly. No one knows anyone else, so you're not really going out on a limb when you introduce yourself. It's a lot of fun—all the parties going on—people like to do it."

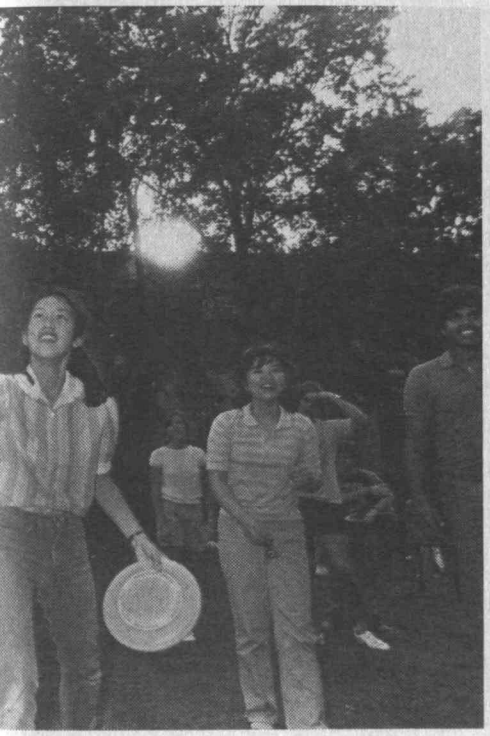
The new class spent the first day introducing themselves to each other. Some found old acquaintances from high school, while others looked for students from

upperclassman from his country was living.

He had looked at schools in Germany and other parts of Europe, but there was no student aid available. He was able to receive aid here, and was interested in the process through which he would get the student employment necessary to round out his financial aid package.

So far, Alex was very glad to be here. "M.I.T. is one of the most renowned schools in the world. There are good schools in Turkey, but none like this."

Ken Gartner had yet to be impressed. After his eight-hour bus trip from Long Island, he gave a mixed review to the gatherings he attended earlier that afternoon. "I'm too well briefed–they sent me too much information over the summer. They can't hold an intelligent conversation with me because I agree with everything they say. I know the Harvard Bridge is 364.25 Smoots and 1 ear long. I know there are 22 intercollegiate sports . . . I have no questions, I've learned nothing new yet."



their part of the country. One eager freshman wanted to know all about the Wellesley shuttle bus—when it ran and where the bus stop was. "As a first impression, they seem very gregarious in comparison to other classes," observed Julia McLellan, senior associate director of admissions. "Nobody's sitting back and waiting for someone to come up to them and introduce themselves. They probably think we accepted them knowing they'd be this way."

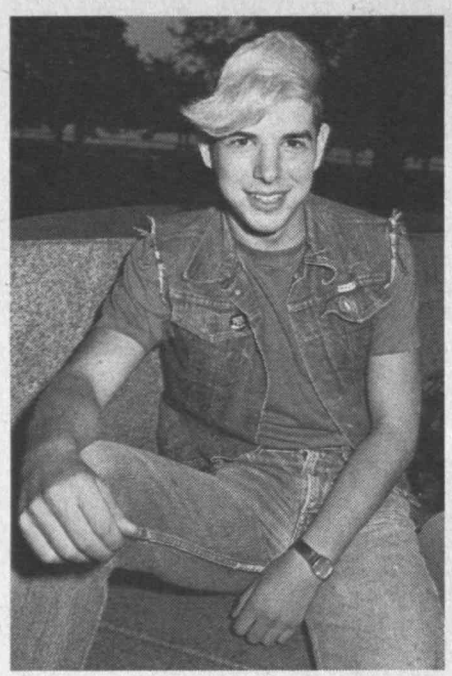
Friday, September 2

"Nobody will talk to us about housing, and that's what we want to know about most. When we ask questions, the students smile and say, "Sorry, talking about that's a rush violation."

Standing in line waiting for food, or sitting in groups, conversation at the freshman picnic was dominated by talk of the impending Rush. However, many freshmen were sufficiently distracted to discuss other subjects. As brilliant as they're supposed to be, it was surprising to find that their interests were the same as most kids their age—rock music, sports, the things they had done in the summer. It seemed as if nobody wanted to be considered a brain—one young man's comment on the velocity of a hacky-sack at the freshman picnic was summarily ignored by his classmates, and in another conversation, a cluster of freshmen were discussing their aversion towards their high-school valedictorians only to discover as the conversation wore on that several of them had been the valedictorians of their high schools.

Yet, when challenged, they seemed eager to demonstrate their ability to think out problems. A discussion on entrepreneurship turned into one on alternative transportation and finally evolved into innovative bicycle design. These kids are faking dumb. "Some hold patents, others have calling cards; they're very sophisticated for their age," says Julie McLellan. "One young man was head of software development at a small company. I said to his father, 'Your son already makes $27,000 a year: why does he want to come here?' "

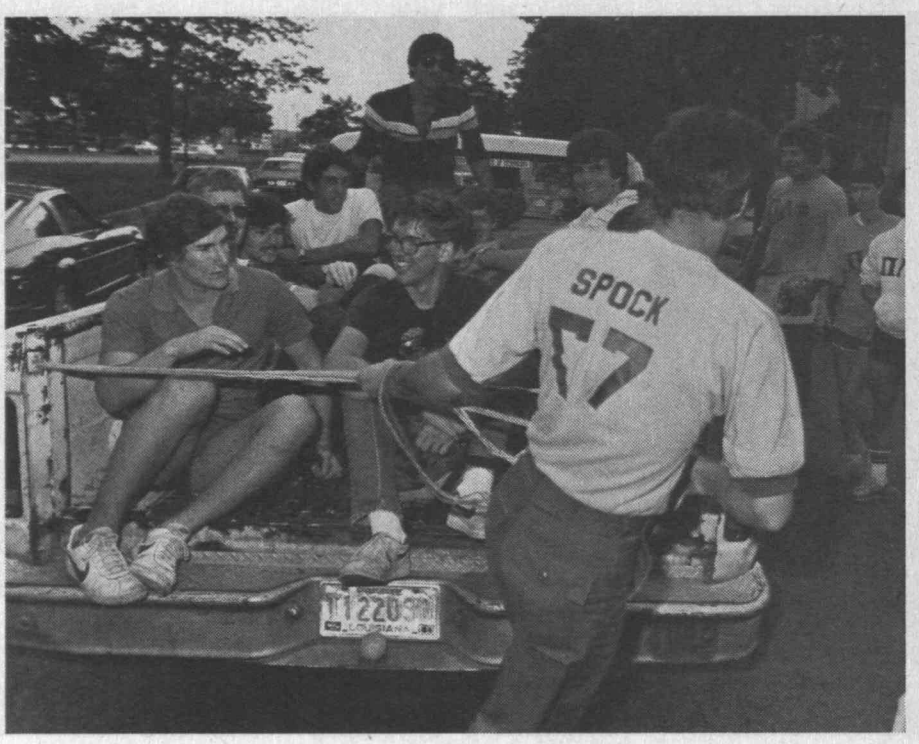
It was a beautiful day for the picnic—a pleasant late afternoon in the hazy Boston sunshine for the



Amidst the post-picnic chaos, with upperclassmen running frantically everywhere and freshmen being led away to a week-end of parties and rushing, one new student stood out in manner and appearance. David Small walked calmly through the din and crowd to a point on the edge of the lawn, where he settled on the grass to watch the activity from a distance.

Long after the famous call "Let the Rush begin!" had faded and the last of the freshmen had left on their odyssey through housing, David was sitting, watching the workers clean up Killian Court and cart away the refuse. He simply figured he didn't belong in a fraternity and elected not to participate.

David says he wanted to come here "because of all the facilities available–all the equipment that's accessible here for me to play with." He also intends to cross-register at Harvard in order to take Japanese. When asked about his distinctive haircut, he said that his parents hadn't seen it. "I got it right before I boarded the bus. I haven't figured out what I'm going to do when



Clockwise from the upper right: Theta Delta Xi brothers and prospective pledges go to a Red Sox game, East Campus decorates itself for R/O week, freshmen consider housing options in the courtyard of McCormick Hall, and Pi Lambda Phi gives freshman a breezy ride to their house across the Charles River.

combined group of faculty, staff, and new and old students on the lawn of Killian Court. After predictable speeches by several administrators and student officers, everyone was asked to rise, stretch, and turn around—there to observe the several hundred fraternity members who had quietly taken positions behind them on the edge of the lawn. "Let the Rush begin!"

Saturday, September 3

Throughout the night, the R/O Center has kept track of the whereabouts of the meandering freshmen by updating a computer database with information phoned in regularly by the house desks. Programmed by an R/O volunteer, the database and its driving software are impressive. By mid-morning, preliminary statistics on the first night of rush are in; close to one-third of the class had spent the night sleeping over in the fraternity system. Breakdowns by house and gender were available upon demand, as was other information, such as how many houses a particular freshman had visited. "Too many visits is a bad sign," commented one R/O worker after noting that one freshman had already visited 12 fraternities. "It means that he's visited so many places that they're all mixed up in his mind. He'll probably end up in a dorm."

The freshmen kept track of every day's events with the *Daily Confusion*, a publication available every morning of R/O week. On this first Saturday it revealed that a discriminating freshman could have his choice of a dozen breakfasts from steak and eggs to gourmet waffles, eleven places for lunch (mostly barbeques), and 20 dinners from New England seafood to Chinese cooking. Obviously, the trick was to be able to talk with your mouth full, meeting upperclassmen and fellow frosh while stuffing your face.

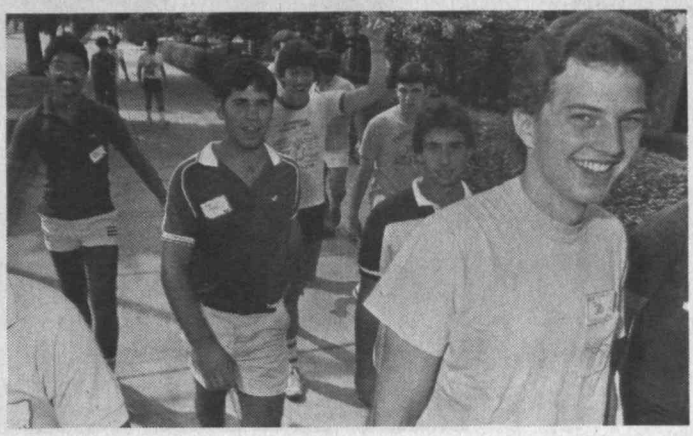
"Everyone asks the same questions: 'Where're you from?' 'What're you interested in?' "

Last night and today, a sort of symbiotic experience was occurring in the fraternities as freshmen and upperclassmen weighed each other as potential housemates. Some freshmen had already caught on to

they come up with my stuff next week. Maybe I'll say I accidentally spilled some bleach on it or something."

As it was beginning to get dark, David decided to go over to the fraternity houses anyway, "to see what it's all about.

"I think what I'll try to do is move into a different dorm every night. Then, if I still can't make up my mind, I'll try something else; ouija board, dice, tarot cards. . . . Oh no! I knew I forgot to pack something."



some of the systems the houses were using to keep their prospective pledges in some sort of order. "If you're new, your name tag has your full name on it. If you passed the first round, your name tag had only your first name on it, and that way all the brothers knew they had to be sure that they had talked to you."

The dormitories, despite the fact that they're open admission, also tried to present themselves the way they wanted to be viewed, in hopes of attracting people of compatible character. McCormick Hall, for instance, is centrally located and has excellent facilities, and it's the only all-female dorm. For these reasons it is consistently oversubscribed, but McCormick was having dance parties, volleyball games, and barbeques anyway trying to attract outstanding freshwomen. "A lot of women end up here by default," explained a house officer, "They're really not pizzazed about living here, they just want to live in an all women's dorm; as a result, they're not into the experience. We want the freshwomen to choose us less because of the security, kitchens, and river views and more because of the people who live here."

Sunday, September 4

After a sleepless night for many, and a full day and a half of Rush, the freshmen are beginning to wise up: two of them were reviewing the Daily Confusion *as they walked along, and one was overheard saying to the other ". . . 'refreshments will be served.' That means soda and potato chips."*

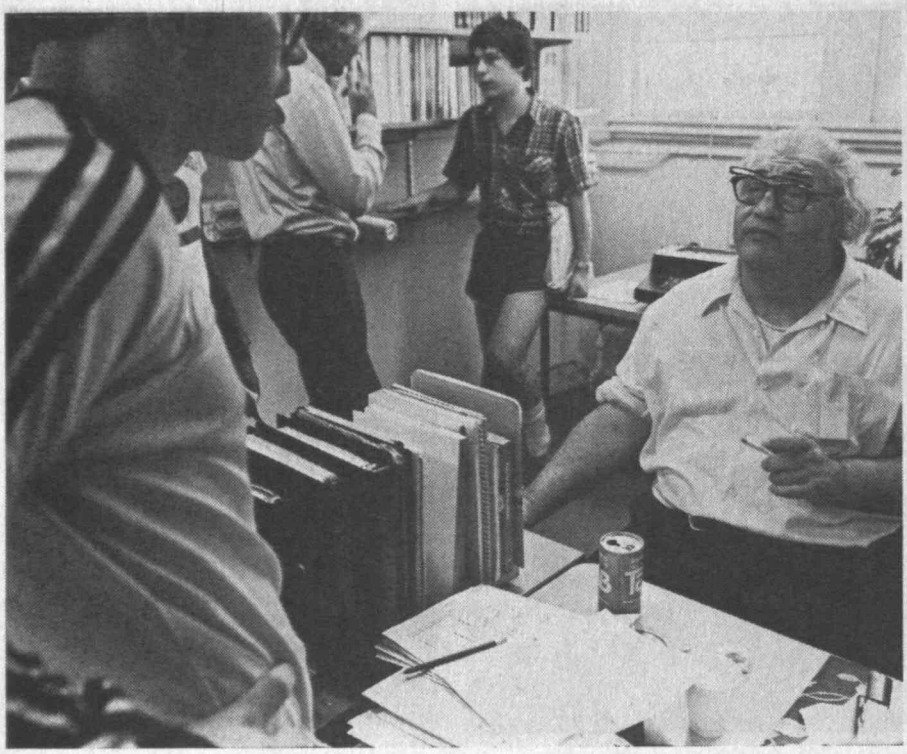
Monday, September 5

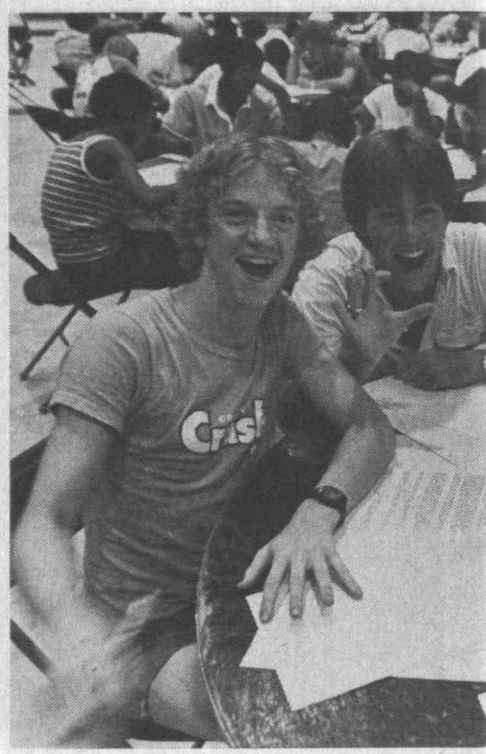
The freshmen turn in their dorm preference cards, listing their choices for on-campus housing.

Even after a weekend of looking, the problem of picking a dorm weighed heavily on Karen Rothkin. "I had put down East Campus, but then someone gave me a hard sell on New House." More than willing to give their share of advice, each of her friends contributed an opinion, but that only seemed to make matters worse. Finally, at a quarter of five, 15 minutes before dorm preference cards were due, it was decided by committee to flip a coin—heads for East Campus, tails for New House. It came up heads, but Karen put down New House as her first choice, discounting the toss.

Although Alexandra Linde has lived the last 17 years in Dobbs Ferry, N.Y., she has Canadian citizenship–one of eight Canadian nationals in the freshman class.

A softball player with a batting average in the "mid 400's," Alexandra played first base for her high-school team, which placed second in its division. When she arrived, she discovered that the starting first-baseman for M.I.T.'s varsity softball team graduated last May, leaving the position open. "I talked to the coach,





"It was obviously a defective coin," she explained matter of factly, turning in her card.

Tuesday, September 6

The first round of dormitory assignments became available—that is, the assignments for students whose first choice coincided with an available room—and many new students moved out of their temporary rooms into their permanently assigned ones, shuttling luggage back and forth across campus. Those who picked dorms that were oversubscribed, and couldn't be assigned, were put into "Limbo," to wait for the next day's housing assignments. Since many assigned freshmen will pledge fraternities, there is a good chance those in Limbo will eventually get into the dorms of their choice, but others start looking again at the dorms they passed up for alternatives.

"Limbo can be a harrowing experience," says Donald Davidoff, '86. "You read all the housing material, do the legwork to look at all the dorms, make the decisions on the one you like, and then you're told you might not get in."

As "Limbo coordinator," a new position he helped to create, Donald is in charge of making sure that the people in Limbo are in good spirits despite their unfortunate situation. "If anyone in Limbo needs something, I'm available as an exclusive aide.

Another person helping disillusioned freshmen is Tricia Kellison, '84, who runs a lounge which serves as a retreat from rushing activities. During the peak of the Rush, while the whole campus is splattered with flyers and posters advertising parties, "Elsewhere" is a place to go where freshman can be with upperclassmen and each other without discussing housing or courses. "After a while, the whole thing can get to be just too much for some people. They can come here, calm down, and organize their thoughts without constant bombardment from their senses."

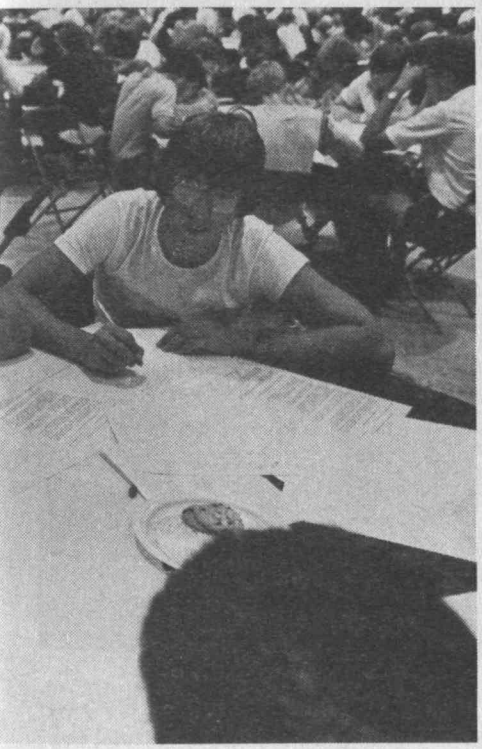
Thursday, September 8

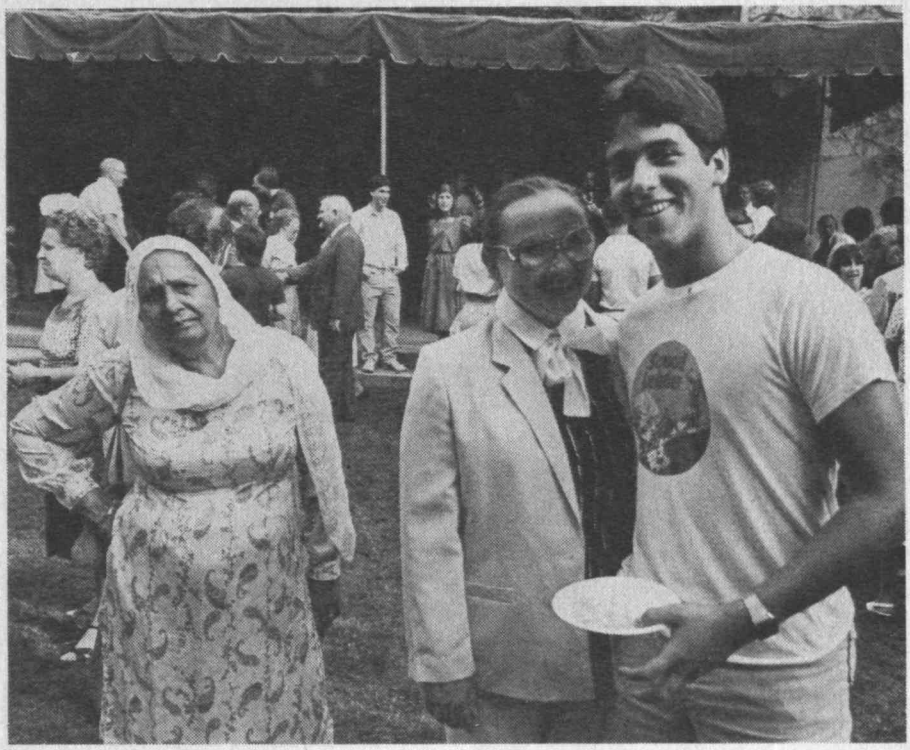
"What am I going to do with classes? After tonight, I already have a full schedule."

It was at the Activities Midway in

and he said that I had a good chance at the spot. It would be great to be starting player right away."

Since women's softball is a spring sport, Alexandra will fill the time in now by being on the sailing team. "Most days I leave Senior House at 10 in the morning and don't return until sailing practice ends at 7. It's a good thing that the sailing pavilion is close to my dorm; otherwise, there are evenings when I'm so tired I might not make it back."





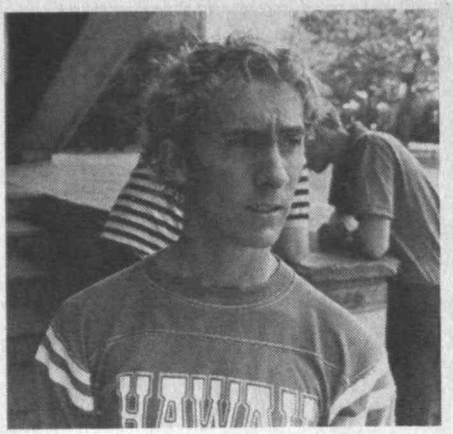
Dupont Gymnasium that many of the entering students first had a glimmer of understanding of the saying, "An M.I.T. education is like a drink from a fire hose." The atmosphere was not unlike a circus sideshow, as seemingly endless aisles of student activities, from the Akido Club to the Zionist Alliance, beckoned the interested freshman to sign up. The general rule of the evening seemed to be to sign up for everything, always having the option of claiming that you're too busy once they called on you to participate.

In the Rockwell Cage next door, M.I.T.'s 22 varsity sports and various other athletic clubs such as frisbee and spelunking talked to interested students and demonstrated athletic prowess. Here, the attitude on both sides was more serious. Freshmen talked to the coaches of the teams they were interested in, trying to get a feel for their chances at varsity positions.

Saturday, September 10

Parents have been arriving yesterday and today with additional luggage for their children, and a cluster of activities had been scheduled specifically for them. In the morning, President Gray led a panel discussion at which parents could ask questions of the faculty and administration present. There was all the usual advice about helping offspring adjust to the realities of a place where 90 percent of the class has always been in the top 10 percent of the class but can't be any

Clockwise from upper right: The Activities Midway; grandmother, mother, and son at the President's Reception; hamming it up at the Freshman Writing Exam; Professor Jerome Lettvin listens intently to a question on freshman academic options.



Daniel Mullins spent the first days of rush going from house to house: "I visited nine fraternities on the first night and another six the next day. It didn't seem I would find any place that suited me until I came upon La Casa as I was going through the dorms."

La Casa, or Spanish House, is one of the foreign language houses in the New West Campus Houses. Daniel had spent six months in Spain as an exchange student and was pleased with this opportunity to maintain his Spanish proficiency.

Daniel has also joined the Experimental Study Group (ESG), which offers an alternative program of study to the standard freshman fare. Students in ESG work under supervision at a self-paced rate. "I like the combination of freedom and responsibility for my own education that ESG seems to offer." By the first week of classes, he had also started working on the yearbook staff, and had earned singing and dancing roles in the Musical Theatre Group's fall show.

This year's first-ever Registration Day picnic sets a happy precedent as it brings the community together before the start of classes.

more—a principal argument for freshman pass/fail grading, said President Gray. Professor Jay Keyser, faculty resident in Senior House, turned into an effective salesman for Ma Bell: "There is something in family support that cannot be replaced. The single most important thing in getting through M.I.T. is the strength of contacts with the family."

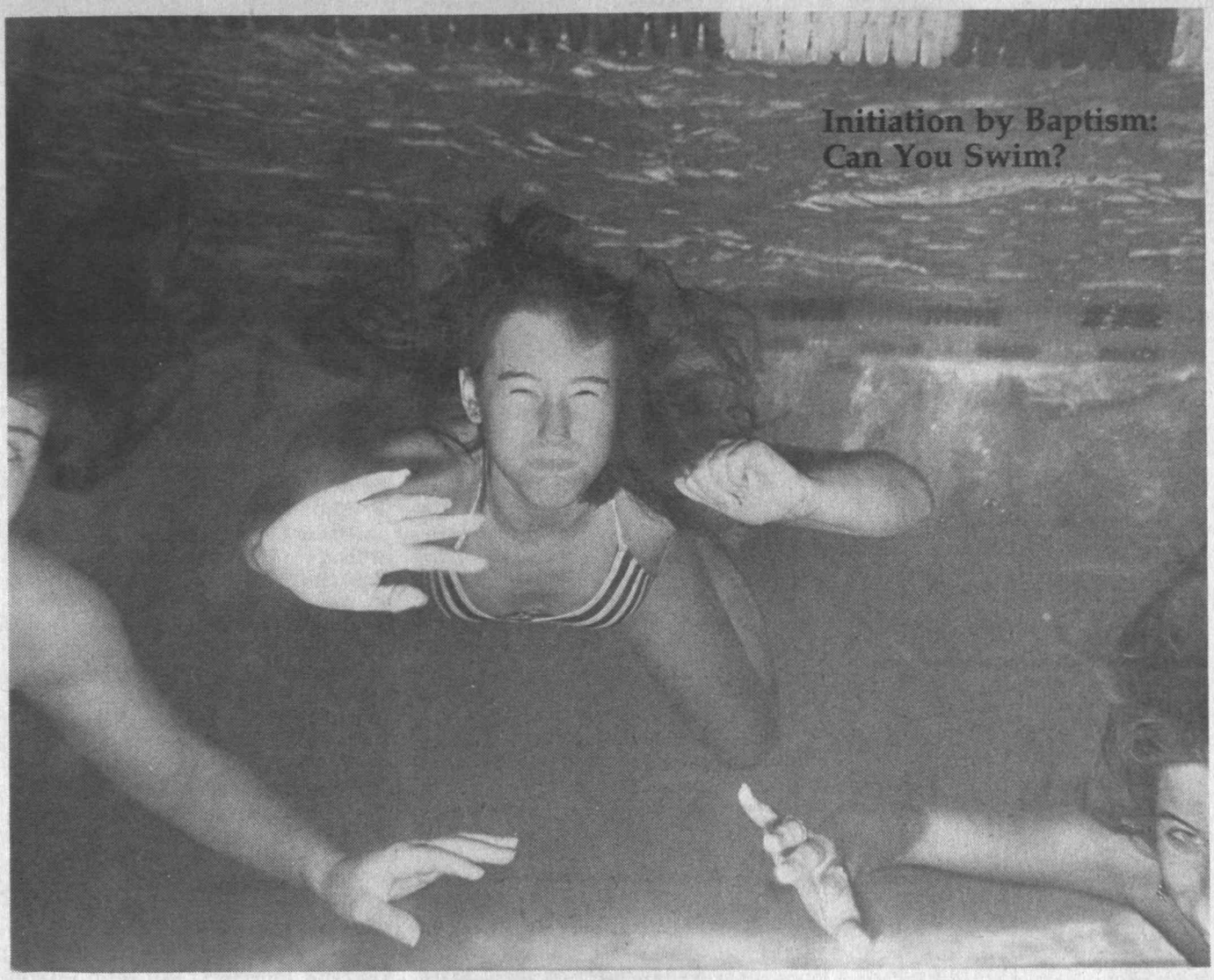
In the afternoon, the freshman class and their parents appeared in their Sunday best for the President's reception. In general, the parents as a group seemed to be in better spirits than they were nine days earlier, when many of them had driven their children to Cambridge for the start of R/O week; they had come to terms with the finality of their children leaving home, and they took comfort in seeing that their children had made choices about where to live and who to be friends with.

Mrs. Modiano was standing in the middle of the lawn as the reception was winding down, looking for her son David, who had abandoned her to go off with a group of classmates. "I hope I can find him before dinnertime," she said, taking another sip from her glass of punch. "I want to give him one last good meal before I leave him to cook for himself."

Monday, September 12

Registration Day. To end this year's R/O week, the entire M.I.T. community was invited to a picnic on Kresge Oval with fried chicken and hot dogs. The Student Center Committee judiciously supplied a swing band for the first part of the event and rock bands for later. Meanwhile, nearby the student-operated Lecture Series Committee clung to tradition despite strongly-worded official sanctions and showed an X-rated movie.

During the Kresge Oval festivities, incoming undergraduates were awarded "I survived R/O '83" T-shirts. For many of them, being away from home and family along with the many decisions to be made in such a short space of time, had been an experience more demanding than they had ever dealt with before; in one short week, the responsibility for their own lives suddenly became their own. They answered the challenge admirably.



Initiation by Baptism: Can You Swim?

Every undergraduate hears the story about the senior who was dragged to the pool on the morning of Commencement, kicking and screaming, to pass the swim test. While the story is probably apocryphal, its basis is very real: passing a swimming test is a requirement for every undergraduate. According to the current registration material, the test consists of "swimming four lengths of the pool (100 yards) with the last 25 yards being allowed on the back." In order to sail or participate in crew, you must pass the additional "small boats" test—tread water for ten minutes after having swum 100 yards.

The idea of a swimming requirement can be traced to Ivan J. Geiger, who was director of athletics from 1947 to 1955. He was a strong advocate of athletics as a part of every student's experience, and he found the Alumni Pool, which had been built just before World War II, an underutilized facility. After surveying some 17 colleges and universities as to their athletic requirements for students, Geiger brought to the faculty—and quickly won approval for—an athletic requirement that included a swimming test. Perhaps partly to justify the latter, he wrote to President Karl T. Compton that ". . . it should be desirable to steer as many incoming freshmen as possible into the regularly scheduled swimming classes. . . . This will greatly reduce the terrific load that would be placed on less adequate athletic facilities and teaching staff and level off the efficiency of instruction and use of facilities." Geiger's new athletic requirement approved in October took retroactive effect on the freshman class that had just entered, whose members were caught somewhat off guard by the emergence of this new demand on their time in the middle of the year. The result was a petition with 500 signatures protesting to the faculty the introduction of a "physical training program" in "an already overcrowded schedule." The requirement, however, was upheld, and physical education, including the swim test, have appeared as part of the General Institute Requirements ever since.

Many a non-swimming student has cursed Geiger's initiative, but to no avail. The registration material every year advises in bold letters that the swim test "must be taken by all freshmen before regular physical education classes start," so that those who can't swim will sign up for beginning swimming as the first step towards completing their athletic requirement. While this guideline is not strictly enforced, special swim test hours are scheduled during the first week of every term. Rarely does anyone fail: most of those who have doubt about their ability to pass register for beginning swimming right off, or quietly retreat to their academic studies for four years, wishing away the day when the letter from their advisor arrives stating that ". . . you have completed all but one of the Institute requirements . . ."—*Peter Mui, '82, with thanks to Helen Slotkin and Kathy Marquis in the Institute Archives for their research.*

Meet a Phi-Beta-Kappa, Water-Polo-Playing Architect

Sports Report/Ken Cerino

Kennneth J. Cerino has been M.I.T.'s sports publicity director since 1979, when he came from similar assignments first at Siena College and then Iowa State University. He was president of the ECAC Sports Information Directors Association in 1982-83.

With all the records assembled and the computing finished, we report with pride that M.I.T.'s men's and women's varsity sports teams compiled an impressive record of 256 wins and only 186 losses during the 1982-83 year. That's 57.9 percent, and it compares with the 214-239 (47.2 percent) record of 1981-82.

The men posted a 158-124 record (56.0 percent). The women were even better—an impressive 98-62 (61.3 percent) compared to 71-90 (44.1 percent) in 1981-82. Sixteen teams (12 men's, 4 women's) had .500 or better seasons. Three squads—rifle 30-0, golf 16-0, and women's cross country 11-0—had perfect records.

Scholarship Plus Water Polo

For the second consecutive year (and fifth time in the last seven years), an M.I.T. student-athlete has received a NCAA postgraduate scholarship. Water polo standout John T. Friedman, '83, was named a recipient of the $2,000 scholarship last June. A three-time All-American, Friedman holds M.I.T. records for most goals in a game (10), season (115), and career (352). Friedman also was a four-year varsity letterwinner, team captain his junior year and co-captain as a senior, and winner in both these years of his team's most-valuable-player citation. Coach John Benedick calls him "by far, the finest water polo player ever to attend M.I.T."

M.I.T. athletic director Royce J. Flippen, Jr., noted that while all this was going on Friedman also was compiling a perfect 5.0 average in architecture and one of the few architecture majors ever chosen by M.I.T.'s Phi Beta Kappa chapter—"a remarkable achievement," Flippen said. "He has the highest qualities of character and is a very deserving recipient of this prestigious award."

Names in the News

Friedman was one of four student athletes named first-team Academic All-American by College Sports Information Directors of America during the summer. The other three: swimmer John S. Schmitz, '83, wrestler Kenneth R. Shull, '84, and women's softball shortstop Louise Jandura, '84. Jandura was an all-around threat on the diamond: in 17 games, she hit .379 (22-for-58) with three doubles and 23 RBI's, and she pitched in two games posting a 1-0 record. Meanwhile, Jandura was compiling a 4.9 grade average in mechanical engineering. She is the Varsity Club president for 1983-84.

Other accomplishments: Bruce F. Klein, '83, captain of the varsity sailing team, received an honorable mention on the 1983 Intercollegiate Yacht Racing Association All-American team.. . . Patrice M. Parris, '85, placed fifth in the hammer throw (171' 5") at the NCAA Division III Outdoor Track and Field Championships to receive All-American recognition. . . . In lacrosse, tri-captains Harry J. Lipschitz, '82, John (Mark) Johnston, '84, and William T. Larkins, '84, along with Mark J. Brine, '85, and Michael J. Ambrogi, '85, were named to the Snively Division All-Star team.. . . Another lacrosse standout, Manuel P. Oliveria III, '82, was selected to the East All-Star team comprised of the best senior players in New England. He also received the team's Ben Martin Award as the senior who displayed the most determination, dedication, and spirit.

Crew Teams Excel

The highlight of the crew season came when Ronald G. Wilkes, '84, and Andrew G. Ziegler, '85, won the varsity pair-oared-without-coxswain race at the Intercollegiate Rowing Association Championships on Onondaga Lake in Syracuse, N.Y. It was only the second time a M.I.T. squad has won an event at the IRA's. An interesting note: Wilke's father Robert, '55, was a member of the M.I.T. varsity lightweight crew team that won the national championship and finished first at the Henley Royal Regatta in 1954, and the coach of that

HENRY WU, '87, FROM *THE TECH*

STEPHEN P. BERCZUK, '87, FROM *THE TECH*

team was Jack Frailey, '44, now director of student financial services at M.I.T. Frailey and Wilkes both attended this year's IRA meet, Frailey serving as a regatta official and Wilkes as a proud spectator.

M.I.T.'s women's varsity four squad—Laura L. Kiessling, '83, Ruth M. Fricker, '85, Elizabeth Bradley, '83, Lillian M. Hill, '83, and Linda E. Mar, '85 (coxswain), finished third behind Northeastern and Radcliffe at the National Women's Rowing Championships in Madison, Wis. . . . Later Bradley and Fricker were at the National Sports Festival June 28 in Colorado Springs, Colo. finishing second among four squads in the varsity pair-without-coxswain race. Bradley and Hill then competed in the Canadian Henley Regatta in August, where they missed advancing to the finals of the women's pair by a scant three-tenths of a second, finishing second in their qualifying heat. . . . Jeanne W. Simon, '86, was a member of the women's four team which won the silver medal at the Bay State Games on the Charles River in August, and Simon, Bradley, Hill, Karen B. Deutsch, '85, and Mar were on the squad which won the women's eight bronze medal at this same event.

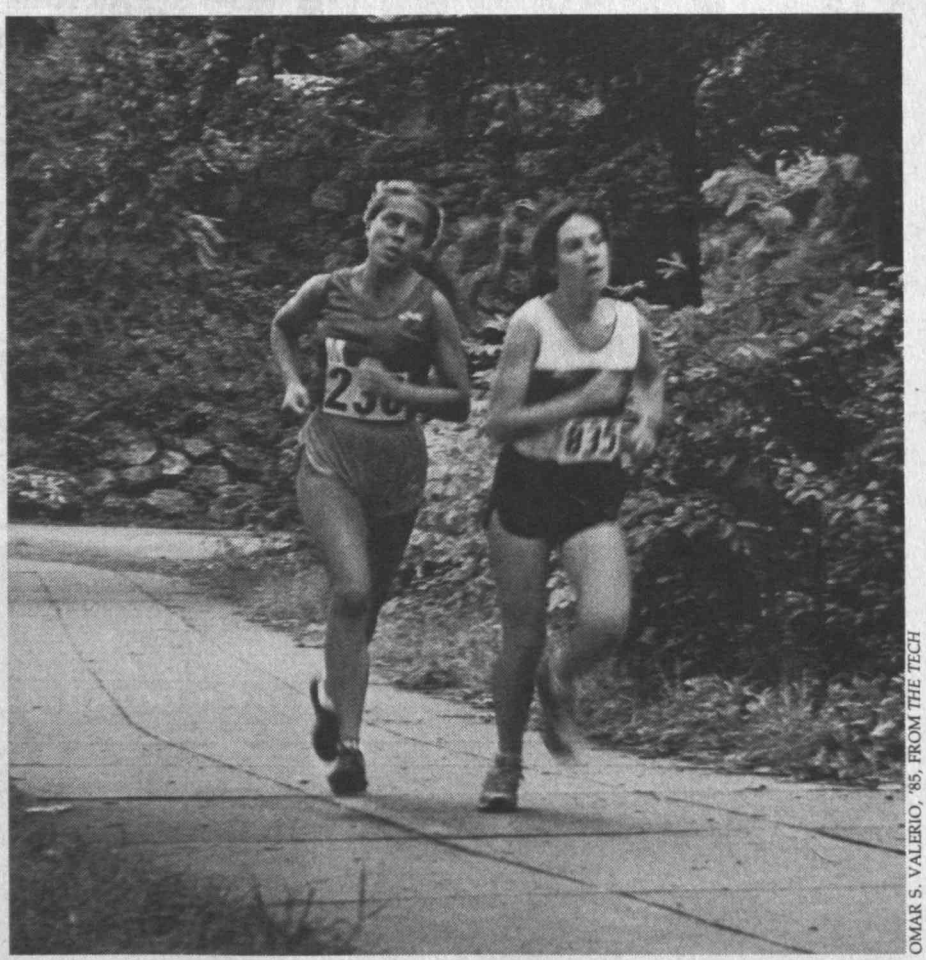
Meanwhile, Kim A. Marvin, '85, had quite a summer rowing for the U.S. lightweight four team which finished sixth in the World Championships in Duisburg, West Germany.

Footnotes on Excellence

M.I.T.'s varsity sailing team qualified for the nationals for only the third time in the last 20 years and finished 11th among 16 finalists in the June regatta in Corpus Christi, Tex. . . . M.I.T.'s highly-regarded women's softball team was ninth among all Division III schools in the nation in fielding percentage (94.0) in the 1983 season.

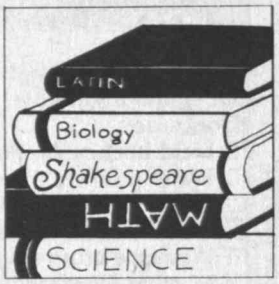
OMAR S. VALERIO, '85, FROM *THE TECH*

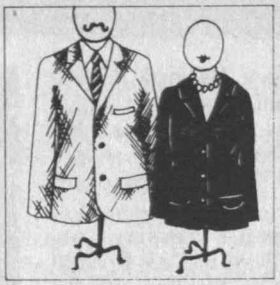
***The Tech*'s photographers capture some fall sports highlights.**
Clockwise:
☐ Field hockey vs. Pine Manor.
☐ Water polo vs. Maine Maritime.
☐ Girls' volleyball vs. Boston College (the "spike" is by Janette Kauth, '85).
☐ Women's cross-country (No. 835 is Marilyn Oberhardt, '86).



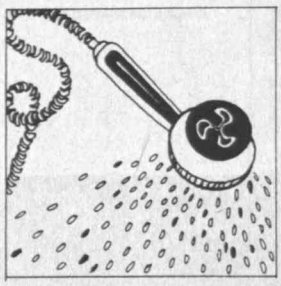
OMAR S. VALERIO, '85, FROM *THE TECH*

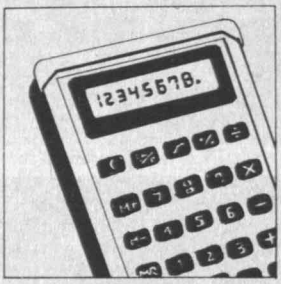
Things for reading, things for packing, things for speeding,

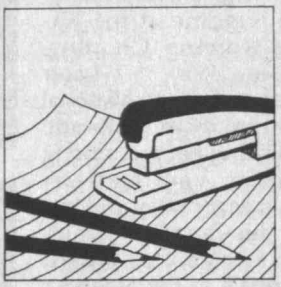




things for cracking. Things for playing, things for dressing,







things for spraying, things for guessing. Things for duty,

and things for soup, things for beauty at

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M.I.T. Student Center

05

William L. Spaulding died on June 14, 1983, in Norfolk, Va., at age 99. Born in Lowell, Mass., the son of a doctor he was a chemical engineer. For 20 years or more he worked for American Cyanamid, first in New York, then in Ft. Worth, Tex. The last year before his retirement in Norfolk he served as a consultant for the company in Holland. He is survived by a daughter and several grandchildren.

I would appreciate hearing news of other members of our class.—**Gilbert S. Tower,** Secretary, 35 N. Main St., Cohasset, MA 02025, (617) 383-0588

06

A report of the death of **Robert S. Pinkham** of South Weymouth, Mass., has reached the *Review* office. Mr. Pinkham died on August 9, 1982 at the age of 99. He is survived by his wife, Sarah, six children, 18 grandchildren and 16 great-grandchildren.

08

At the Alumni Day luncheon Friday, June 10, the Class of 1908 was represented by **Franklin Towle** and by **Harold Osborne** and his wife. Franklin says he needs help in walking now, and he was persuaded to come by the fact that his son was available and came with him. The Class of 1908 was recognized by the chairman, who asked Frank and me to rise and be applauded.

The fact that Mrs. Osborne and I were at our summer home in Hopkinton, N.H., simplified the task of coming down to this luncheon; it is about an 80-90 mile drive.

Frank seemed very well, and after luncheon adjourned, he and I went our separate ways and headed for home. During the luncheon, Dr. and Mrs. Killian came down to chat with us, and at the adjournment Dr. Gray came to the table and expressed pleasure that we had come and that the class of 1908 was still represented. As far as we know the next oldest class to have any representative was 1913.

The records of the Alumni Association now indicate that only three members of the class of 1908 are still living. The third, **Leo Loeb**, lives in Manhattan, but is now in a nursing home, and in response to my letter urging him to come to our 75th Reunion replied that it wasn't possible.

The main feature of the luncheon was, as is usual, the announcement of gifts by the reunion classes; the 50th, 40th, and 25th. A brief talk was given by President Gray.

This past week, Mrs. Osborne and I took a trip down to Cambridge to the 97th birthday of a lady whom I have known since 1899. She lives at 110 Memorial Dr., which is practically a part of the M.I.T. campus. I was able to have a short visit with Dr. Karl Wildes, who was a professor in the E.E. department, and who is preparing a history of M.I.T.—**Harold Osborne**, Secretary, Penacook Rd., Contoocook, NH 03229

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We regret to report the deaths of four classmates. **John Scoville** of West Hartford, Conn., died December 22, 1982 at the age of 93. He worked as a consulting engineer most of his life. Also he was employed by Sanderson Porter of New York and in later years he worked with Ernest F. Carlson Construction Co. of Springfield, Mass. He was a member of the Hartford Golf Club, the Fernleigh Bowling Club, and the Old Guard. . . . **David St. Pierre Gaillard** of Washington, D.C., died on March 26, 1982 at age 92. He was born into an Army family in St. Augustine, Fla., and grew up at various military installations, graduating from Western High School in Washington, D.C. At M.I.T. he studied electrical engineering. In 1917 he was commissioned in the U.S. Army. Then in 1922, he transferred to the Reserves and settled in Washington where he became an investment manager until retirement in 1971. During World War II, Colonel Gaillard was an ordnance officer in the Army. He was a member of the Metropolitan, Gibson Island, Chevy Chase and Army and Navy Clubs, the Huguenot Society of Washington and the Panama Canal Society. He is survived by his wife, Mona, and two children. . . . **Allston T. Cushing** of Sepulveda, Calif., died May 7, 1982. While at M.I.T., Mr. Cushing studied civil engineering. . . . **Robert E. Morse**, of Sandwich, Mass., died on June 7, 1980. He received his M.I.T. degree in electrical engineering.

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We have received belated and brief notices of the deaths of three classmates. Mrs. Mary E. Harris, daughter of **James A. Cook**, informed us of his death on September 20, 1982. He had been residing in Marblehead, Mass. . . . **John W. Connolly**, who took his degree in civil engineering, died June 26, 1981. His address was Ponte Vedra Beach, Fla. . . . Finally, we learned from John F. Robinson, M.I.T. class of 1922, that his brother, **Kenneth C. Robinson**, died of pneumonia at the age of 96 on April 26, 1982 in Portland, Oregon. While at M.I.T. Mr. Robinson studied mechanical engineering.

14 70th Reunion

In response to my June letter to **Victor J. Brownson,** Mrs. Brownson wrote that because he reached 92 in May, he felt himself relieved of responsibility for letter-writing; but he approved her writing for him. They live in Massapequa, N.Y., and though their home is not on the water, they have the benefit of cool Long Island breezes in summer. Vic enjoys sitting outside reading, doing a little flower gardening, and watching the activities of the various birds that come to the bird bath. He likes to keep up with the doings of the American Society of Civil Engineers. The Brownsons have a small retirement apartment in Whiting, N.J., and they try to get there about once a month for a week or so, just for a change. Vic is somewhat bothered with arthritis and doesn't drive any more, but stays remarkably well for his age. Though they don't travel much, they flew to Atlanta last fall to visit family, and were driving to the Cape in early August to be with more of their relatives. Mrs. Brownson ended her letter by saying that she and Vic keep busy and happy and enjoy life.

Philip A. Russell wrote in July that since he retired earlier this year from the Franklin Custodian Funds, he's been living quietly at his home in Scarsdale, N.Y. His health has prevented him from playing golf or planning long trips. Phil added that his wife died several years ago and that his eldest daughter has since been looking after him. . . . Word came in July of the death of **Raymond J. Cunningham** on June 15, 1983. I'm seeking information for a later note about him.—**Charles H. Chatfield,** Secretary, 177 Steele Rd., West Hartford, CT 06119

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I am writing this column on Labor Day morning. I have been on vacation in Kankakee, Ill., about 60 miles south of Chicago and returned home to find an August 30 *Review* deadline. So hope we can still make this issue.

Evers Burtner wrote and reported that in early May his wonderful former student, Jonathan Leiby, '58, picked him up, drove to Fall River where he saw the fine marine museum and a 250-ton tug he designed launched by means of a heavy-lift derrick from New York.

Then, on the first day of July, Evers had a wonderful trip to the Thousand Islands with his neighbor, Harry Card, his family, and his steam launch *Oliver*. In company with 14 other steam launches they steamed from Kingston, Ontario, to Guananoke hence to Alexandria Bay, then to Clayton and back to Kingston. Perhaps a bit tired—he had a case of pneumonia—but now is much better.

Charles Loring Hall pleased me again, and sent some selections from his diary which he kept from 1907 to 1919. The following items cover the period June 23 to December 31, 1911. He feels the most interesting part of his diary covers the period from 1915 to 1917, when he adventured in China and Siberia. Now here goes:

"Spent the summer of 1911 selling aluminum cooking utensils door-to-door on commission. Made enough to pay my tuition for the first term.

"*September 23, 1911*—Went to M.I.T. and registered. Bought some books. Saw Eddy, Dunn and Hauser. Got a haircut (25 cents).

"*September 27, 1911*—Took 'Speed Test' in Mechanical Drawing. Hope to pass it and get out of first-year drafting classes.

"*September 28, 1911*—Went to Armory for first time. Was measured for a uniform. Had lunch at

Walter Metz, '16, now a California resident, celebrated his 90th birthday with a visit to the Waltham Museum. While in the area 100 people turned out to honor him and attend his banquet at the Holiday Inn in Waltham.

Walter, seated in a Metz car (above), is the son of Charles Metz, the largest car manufacturer east of Detroit at the turn of the century. By 1914 the operation had sold over 7,000 cars, enjoying financial prosperity until the war broke out.

Driving a Metz "22," Walter sped in for a first-place finish in the 1913 National Glidden Tour, a major long distance auto race. *(Photo: Donald Brennan)*

the Union.

"September 30, 1911—Freshman dinner at 6:45. Followed by speeches from prominent people of the Institute. Then marched four abreast through streets of Boston, capturing sophomores along the way. Had a final battle with 1914 men in front of the Union. Home at 12.

"October 2, 1911—Had our first 1915 football practice at Tech Field.

"October 3, 1911—First lesson in Military Service. Major Cole talked about gun construction and types of powder.

"October 5, 1911—Found I did not pass the 'Speed Test' so will have to take Mechanical Drawing. Disappointed. Heard talk by Rev. A.A. Stockdale at the Union. Subject 'The Road to Cynicism.' Interesting.

"October 11, 1911—M.I.T. Corporation announced new site had been selected in Cambridge along Charles River Esplanade.

"October 23, 1911—Practice as usual in afternoon. **Frank Scully** came out the first time to play quarter-back. He is a corker. **Dix Proctor** there too.

"October 25, 1911—Played our first football game of the season. We beat Winchester 17 to 0. I played right guard. Went to dinner with **Wardwell** at his fraternity, Phi Sigma Kappa. Had a great time.

"October 28, 1911—Tried to get a ticket for the Harvard-Brown game, but couldn't get one for less than $3.50, so went to the Orpheum Theater instead (20 cents).

"November 3, 1911—Field Day! 1915 won it 6-3. In football we won 3-0. The relay race went to 1914. We won the Tug-O-War on the third trial. In the excitement of the victory I found myself hugging a drill corporal I didn't like and everybody was trying to fly at the same time. A great day!!

"November 4, 1911—Got a haircut and shampoo (40 cents). In the evening attended a dinner given by the Advisory Council to Field Day contestants. Had a corking meal, then some fine speeches by President Maclaurin, Dean Burton, Dr. John Duff, '81, (who came by mistake on his son's invitation) and Frank Kanaly, the coach. Came home with **Carl Dunn**.

"November 8, 1911—First five weeks' report: Chemistry P. English P, Free Hand Drawing L, German P, Math P, Mechanical Drawing P, Trig C.

"November 11, 1911—After classes went with **Freeman** and **Dunn** to Tech Field to try out for the DuPont Cup for all-round athletics.

Put the shot 25 feet, high jump 4 feet 4-1/2 inches, mile run in 5 minutes 47-4/5 seconds. Scored 28 points. I was all in.

"November 15, 1911—Tech beat Brown in the Cross-Country race 45-40. Found I came out third in the DuPont Cup. **Wilson** won it. **Larry Quirk** and I did some work at the Field.

"November 29, 1911—This noon I went over to the Gym and ran a mile and a half before lunch. Major Cole let us out early from drill, as some of the fellows wanted to get started home for Thanksgiving. He's a good sport.

"December 15, 1911—Came home after drill, then went to the annual Tech Winter Dance and Concert. It was quite a swell affair.

"December 18, 1911—Went to see Dean Burton this noon and was assigned to an advisor, Professor H.W. Hayward of Course II. He in turn introduced me to sessions in Course I and II to get some help in choosing a course. They weren't much help.

"December 21, 1911—Professor Spafford held a Civil Engineering Conference to explain the duties of a Civil Engineer. Also told us about the new summer camp at East Machias, Maine. **Kerstein** and I went to the Orpheum. Bought a two-pound box of Lowney's best chocolates ($1.35) to take on my date with Marguerite tomorrow."

Now, Fifteeners, I hope you have enjoyed some more of **Loring**'s diary. I think it is a terrific idea, and challenge the rest of you to come up with some great notes for me.

Hope each and every one of you have a marvelous holiday season!—**Joyce E. Brado,** Class Agent, 491 Davison Rd., Apt. 9, Lockport, NY 14094

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Had a nice letter from **Dan Comiskey** and he reported that he and Grace had a nice summer and were able to drive in the country most every day. Also received an interesting newspaper clipping telling us about **Walter Metz** and his recent return to visit the old homestead in Waltham, Mass., after an absence of 60 years: "Walter Metz, son of the city's automobile magnate Charles H. Metz took a nostalgic tour of the Gore Estate where he lived as a boy and shared personal anecdotes with local historians. . . . Metz recalled driving a Metz car in the week-long Glidden Tour in 1913. At one point, Metz said, the crew had to pick up the car bodily and lift it out of a mudhole. 'Roads like those we'd consider impossible these days,' he said. Metz also remembered riding in the forward steering seat of his father's famous 10-seat bicycle once, when the front wheel got stuck in some tracks, spilling all nine riders on the seats behind him to the ground.

"Metz recalled an airplane meet his father held on the estate grounds, one of the first airplane meets to be held in the country. 'I remember Bleriot (a plane owner) hooking his plane up to a tree with a scale attached to see what its thrust was,' said Metz. He said that while a student at M.I.T., he designed an airplane that had just enough power to 'hop around the airfield.'

"The visit to Waltham is a 90th birthday present from his family, who wanted him to be able to 'return to his roots,' said his daughter, Marilyn Visel, who accompanied Metz and his wife Marie on the trip.

"Now retired after a long career as a house and apartment builder, Metz lives in Palm Springs, Calif. where he plays a lot of golf."

Heard from his nephew that Millie and **Charlie Reed** had a great summer in Maine again.

Have mailed to all our classmates an urgent request for newsy letters for future columns. The answers provide a welcome insight into the activities of old friends. Keep eating, drinking, walking, breathing—everything in moderation, and of course, write to us.—**Bob O'Brien**, Acting Secretary, H.E. Fletcher Co., Groton Rd., West Chelmsford, MA 01863

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We have the usual dearth of news from classmates during the summer, except for a letter from **Georgius Cannon,** who made a mark as Utah's leading architect. We have been good if infrequent pen pals.

He writes, "I am well except for my walking. My doctor thinks I may have had a slight stroke which affected my right leg. If I had one, it seems not to have affected my brain, for (to me at least) my mind seems as clear as ever. I could part with all my physical gifts if only I can retain my mind.

"I read a lot and think good and stimulating thoughts. I have read recently *The Flowering of Ireland, The Black Death, Keeping Faith, Crisis, Descent from Glory, Poets in their Youth,* and *The Wheat and the Chaff*—all good companions.

"Because I am housebound due to my inability to walk well, I know nothing of what goes on locally with the M.I.T. group. They send me their notices, but all the names are strange to me. As I approach my 92nd birthday, I am surprised to be so old and also to be so well. I read of a man 123 years old and a Japanese 135 . . . who knows?"—**Max Seltzer,** Secretary, 1143 Beacon St., Brookline, MA 02146; **Leonard I. Levine,** Assistant Secretary, 519 Washington St., Brookline, MA 02146

19 65th Reunion

View, a Western Electric Co. magazine in its May/June 1983 issue carried an article about our classmate **Timothy E. Shea**. The occasion was the 25th anniversary celebration last April of its Engineering Research Center which is located near

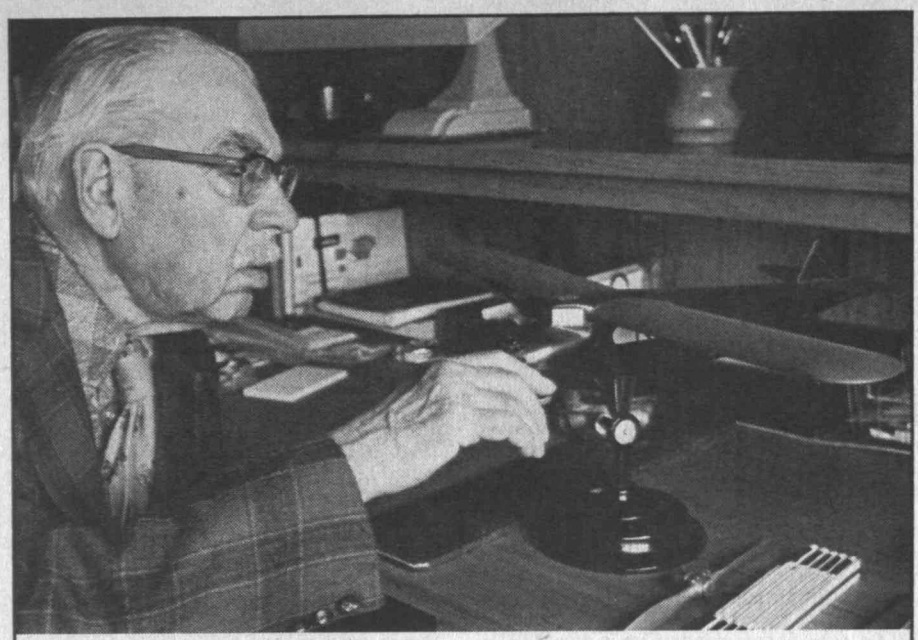
Princeton, N.J. It was dedicated to the man who realized the need for something that had never before existed—a manufacturing research laboratory. A bronze plaque was hung crediting Tim Shea with foreseeing this need for long-range manufacturing research to help the company (of which he was vice-president of engineering, 1957 to 1963) maintain its leadership position in the telecommunications industry. Just another example of the accomplishments of classmates of M.I.T. in 1919, and I am sure you all join with me in congratulating Tim.

We regret to report the passing of **Dean Webster, Jr.** Dean was our class agent for many years and was active in our class affairs. He died after a long illness at the age of 85. He was the owner of Webster Grain Co. in Lawrence, Mass. He leaves his wife Mina, a son Dean K., a daughter (Mrs. Jean W. Post), a brother Walter, and five grandchildren.

Also we report the passing of **Alan B. Miller** in his 85th year after a brief illness. Alan, who resided in Florida, was a close business associate of mine for several years with Singer Manufacturing Co., and I held him in high regard. He was somehow slotted with the Class of 1919 but considered his class to be 1918. For this reason he was not active in our class but was a loyal son of M.I.T. He is survived by his wife Sara L., three sons (Alan Jr., Edwin D., and David F.), a daugther (Mrs. Elizabeth C. Ellwood), 12 grandchildren, and one great-grandchild.

We also report the passing of **Everett Doten** on February 1, 1982. Doten was a member of our reunion committee, and we miss him.

Received a postcard from Barbara and **Don Way** while they were vacationing in New Hampshire saying, "Here's to the 65th reunion." And in closing let me say to you, "Here's to the 65th reunion." By the time you read these notes you will already be reminded of the reunion by a mailing from your committee. Happy holidays.—**W.O. Langille,** Secretary, Box 144, Gladstone, NJ 07934



Mason's Island (Conn.) resident John G. Lee, '21, studies a model of a monoplane (one set of wings)—the Fairchild—he designed approximately a half-century ago. Two planes he designed are on display at the Smithsonian Institute in Washington, D.C. His book, *It Should Fly Wednesday*, experiences in the pioneering days of aviation, is just about ready for takeoff. (*Photo:* The Compass, *Mystic, Conn.*)

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Here is the promised information about our class president **Norris Abbott,** who died on July 19. Norrie lived in Providence all his life. He served as senior vice-president and assistant treasurer of the Manufacturers Mutual Fire Insurance Co., with whom he had been associated for 40 years. An active leader in Masonic circles, he was a port master of Mount Vernon Lodge No. 4, a past high priest of Royal Arch Chapter No. 1, thrice illustrious grand master of the state Grand Council, a past master of the state chapter of the Rose Croix, and grand representative of the United Grand Lodge of England. He served as state deputy of the Supreme Council, Order of De Molay. He was the oldest living past potentate of Palestine Temple and grand historian of the state Grand Lodge.

Norrie was a veteran of World War I, serving in the coast artillery. He was a member and permanent deaconate of the Central Congregational Church, a member of the Providence Art Club, the Sons of the American Revolution, the University Club, and the Rhode Island Historical Society. He was the first president of the League of Rhode Island Historical Societies. He served as president and honorary trustee of the Greater Providence YMCA and a member of its national council. He was past president of Wannamoisett Country Club and of the Squantum Association. (Many will recollect that he hosted the class's 50th reunion at Squantum.) He was formerly a trustee of Bryant College and a director of the Roger Williams Savings and Loan Association and the Emma Pendleton Bradley Hospital. He was an honorary director of Old Colony Cooperative Bank.

A resident of 1180 Narragansett Blvd., he leaves his wife, Betty, a son, and a grand-daughter. He served his class diligently and faithfully as permanent class president. He will be sorely missed by us all.

In the last issue reference was made to an interesting and useful patent issued to **Abe Shlager.** I promptly wrote Abe an acknowledgement using the address in North Miami Beach contained in his communication, but, to my surprise, my letter was returned marked "undeliverable." If you happen to see this, Abe, please clear up the mystery.—**Harold Bugbee,** Secretary, 21 Everell Rd., Winchester, MA 01890

Ted Rose, '21

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Edwin L. (Ted) Rose of Sierra Madre, Calif., one of our most distinguished classmates, died on July 7, 1983. News of this came from Assistant Secretary **Sam Lunden,** a close friend of Ted's. Sam wrote, "I was sorry to lose Ted. We had been visiting with him and his wife Rosalie a couple of times a year. In May Ted called me and said he hoped we could get together before we left for Cape Cod. It didn't work out. Ted was one of the M.I.T. greats, a statesman and a scholar."

A long article on the career of Ted Rose was printed in the classnotes in July 1977. The highlights of his career are repeated here. Ted and Sam Lunden were classmates together at Caltech before coming to M.I.T. At that time, Ted was the youngest man to have graduated in Course VI-A. He continued graduate studies and taught courses in electrical engineering and electrophysics at M.I.T. In 1926, he was asked by the Department of Interior to be the supervising engineer for power generation at the Coolidge Dam in Arizona. He also became deeply involved in the structural design of this, the largest multiple dome dam in the world.

Ted returned to Boston for a period of consulting and then moved to Waterbury to become chief engineer of the Waterbury Tool Co. Here he was instrumental in the development of electro-hydraulic and mechanical loading systems and fire controls to be used on 16-inch gun installations on battleships. With the advent of World War II, he was asked by Vannevar Bush to serve on the National Defense Research Committee. He worked on high speed weapon firing, radar systems and other areas.

He was a participant in the Manhattan Project and for his work received a presidential citation signed by Harry S. Truman in commendation for his contribution to the war effort.

Ted became the technical director of Redstone Arsenal from 1959 to 1963 and set up an organization leading to the development of tactical missiles and space technology. He later worked on hydrofoil developments for the U.S. Navy as director of research at the Miami Shipbuilding Corp. Ted is listed in the International Who's Who of Intellectuals (Vol. IV). We salute a most distinguished classmate. Our sympathy goes out to his wife Rosalie.

One other death is reported this month. That of **Weston Hadden** of Bennington, Vt., on June 14, 1983. Hadden was a staff engineer for the New York Telephone Co. and retired in 1952.

A card just in from Claudia (Mrs. **Josiah) Crosby** tells of their spending their summer in Maine. All has been well with her and Josh and they were planning to return to Sarasota, Fla. early in September.

A note from Marion (Mrs. **George) Chutter** mentions **Winnie Wood Foss** having dropped in to see her. Marion gives a change of address effective August 1: 5 Garden View Terrace, Yarmouthport, Mass. 02675.—**Sumner Hayward,** Secretary, 224 Richards Rd., Ridgewood, NJ 07450; **Josiah D. Crosby,** Assistant Secretary, 3310 Sheffield Cir.,

Sarasota, FL 33579; **Samuel E. Lunden**, Assistant Secretary, 6205 Via Colinita, Ranchos Palos Verdes, CA 90274

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As this is written, the Boston area members of the Industrial Applications Society plan to hear a talk at the Arthur D. Little establishment in Cambridge by our energetic **William B. (Bill) Elmer** entitled, "Mandatory Adoption of the S.I. Metric System—a Tragic Waste for the United States.

Summer has effectively shut down correspondence from classmates, so there is nothing to add other than to say, happily, that no obituaries have arrived in the last six weeks. Statistically we are now down to the last 25 percent, so write now while the opportunity remains. A note for the nautically minded: if you take the ferry from Portland to the islands in Casco Bay, one of my grandsons may be the captain on your particular trip—but not to worry, he's qualified up to 100 tons. And some nostalgia for the golfers: I saw Jones win his first open at Inwood in 1923 and I walked the full 35 holes at Baltursol in 1926 when he lost the amateur to George Von Elm 2 and 1. Also in my scrapbook is a good newspaper photograph showing amateur champion Jess Sweetser being carried triumphantly off the green at the Country Club in Brookline in 1922 on the shoulders of **Abbott (Ab) Johnson** and Johnnie Ballard, '23, the donor of Ballard House in the West Campus.—**Yardley Chittick,** Secretary, Box 390, Ossipee, NH 03864

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The quinquennial meeting of the Class now is past, and the 65th Reunion is waiting to be planned. Now classmates must be taking a holiday after the labor of planning the 60th, as we have received no evidence of activity since our outstanding reunion in Cambridge and Cape Cod.

Donald Watson Height died on June 5. He was born in 1897 in Manchester, Mass., and he prepared at Manchester High School and Brown University before entering M.I.T. as a sophomore. He received a B.S. in mechanical engineering. He was a member of the Phi Gamma Delta fraternity, Cosmopolitan Club, and Mechanical Engineering Society during his undergraduate days; married Katherine Ellis of Melrose, Mass., had a son Donald W., Jr., and a grandson, Donald M. After a year at M.I.T. as an assistant in the Steam Laboratory, he entered the educational field as assistant to the assistant comptroller at Harvard University where he stayed four years. He served as business agent, Arlington (Mass.) Schools; business manager, Cranbrook School, Bloomfield Hills, Mich.; and business manager, assistant treasurer and then comptroller at Wellesley College until retirement. During World War I he was a second lieutenant in the infantry. He was a Republican and Congregationalist. His principal recreation was golf.

Through the courtesty of classmate **Edward C. Rue,** we have learned that **Elton William Willis** died on July 24, 1983, at Venice, Fla. Born in New Bedford, Mass., April 10, 1901, he prepared at New Bedford High School and was awarded his B.S. in electrical engineering. During his undergraduate years, Elton was a member of the Electrical Engineering Society, Tech Show Orchestra, and M.I.T. Orchestra all four years. He married Doris Adams of New Bedford in 1930. They had one daughter, Elizabeth Scholter, a granddaughter, Ellen, and a grandson, Eric. Almost his entire career was occupied as a manufacturer's agent representing the Electric Power Equipment Co., ITE Circuit Breaker Equipment Co., Burndy Engineering Co., Joslyn Co., and Clark and Mills Electric Co. of which he was vice-president and treasurer. From 1960 to his 1964 retirement, he was administrator for the School of Practical Art. He was a member of the American Institute of Electrical and Electronics Engineers; Vermont Electric League; Essex County Electric Club; secretary of Electric Institute of Boston and the University Club; and chairman of the Needham Transportation Committee. A Republican and Protestant, he enjoyed swimming, gardening, and bridge.

Industrialist **Kenneth Clark Kingsley** was awarded his B.S. degree in business and engineering administration. Born in Binghamton, N.Y. in 1900, he grew up in Los Angeles, Calif., and died at Newport Beach, Calif., June 9, 1983. He prepared at Hollywood High School. After 14 years as a chemist with the Los Angeles Soap Co., he joined the Norris-Thermadore Co., where he became vice-president. In 1951, he became president of Costa Mesa Kingsley Co., manufacturers of prosthetic limb components. After serving as school trustee in La Canada, he was a member and past commodore of the Lido Isle Yacht Club, a member of the Lido Isle Community Association, the Newport Harbor Yacht Club, and the 552 Club of Hoag Memorial Hospital. He is survived by his wife, Adelaide, a daughter, Katherine Truesdell, a son, Gerald, five grandchildren, and one great-grandson.

Dorothy Walcott Weeks, Wellesley '16 and S.M. '23, M.I.T., was born in 1893 and grew up in Washington, D.C. She received a Wellesley Alumnae Achievement Award in March, 1983. After two years of chemistry in a Washington high school, she began chemistry at Wellesley at the second year level. She tutored classmates throughout college. After graduation, she taught at Fairmont Seminary in Washington. This was followed by jobs at the Bureau of Standards and the U.S. Patent Office. She received a M.S. in retailing from the Prince School of Business at Simmons College, and was supervisor of hiring of women at Boston's Jordan Marsh Co. After two years, she enrolled at M.I.T., where she received her Master's Degree in physics and taught in the Physics Department for four years, getting her Ph.D. there in 1930 under the famous Dr. Norbert Weiner, her thesis supervisor in mathematical physics. She was the first woman ever to earn a doctorate in mathematics at M.I.T. She continued teaching, lecturing, and research. While teaching at Wilson College, she won a Guggenheim Fellowship to study the optical spectrum and at the same time did research in spectroscopy at M.I.T. Many honors came to Dr. Weeks after retirement, including honorary Ph.D.s from the Medical College of Pennsylvania and from Regis College—**Gerald A. Fitzgerald,** Assistant Secretary, 128 River Dr., Hadley, MA 01035; **Richard H. Frazier,** Secretary, 7 Summit Ave., Winchester, MA 01890

24 60th Reunion

The Reunion Committee held its nth meeting July 26th, with **Ray Lehrer** hosting as his luncheon guests at the Algonquin Club, **Don Moore** (Chairman), **Russell Ambach**, **Donald Fife**, **Edward Moll**, and **Herbert Stewart**. Wearing his hat as Class Executive Vice President, Don Moore read a letter from **Phil Blanchard** regretfully resigning as Class President due to increasing pressure of family responsibilities. Under the last Nominating Committee rules, Don automatically becomes Acting President to fill out Phil's unexpired term. His first act was to appoint a Nominating Committee, with Phil as Chairman, to report a slate at the coming Reunion. The Class officers thank Phil for his accomplishments as Class President, and send regrets for the circumstances which occasioned his resignation.

The Reunion Committee delegated to Russ Ambach the finding of a Program Subcommittee Chairman, which he promptly did in the person of **Dick Shea**. Dick has been provided with a list of ten or more suggestions for entertainment the Friday afternoon, Saturday morning, and Saturday afternoon of the reunion, but his subcommittee wants prospective attendees to write him your ideas and preferences as to events, tours, visits, etc. so that they can fit in what you want. Please do this immediately upon reading these notes so that your vote is in before the program becomes frozen. R.F. Shea's Florida address is 255 Inner Dr. East, Venice FL 33595, and Massachusetts address is 7 Berkeley St., So. Yarmouth, MA 02664.

We are saddened to report the death of **Theodore M. Burkholder** on August 4. Ted was born in Hillsboro, Kansas, and earned both bachelor's and master's degrees at M.I.T. He had a stunning bass voice and was the first undergraduate to be student leader of the M.I.T. Glee Club. Later he sang bass in church choirs at Kings Chapel, Boston, and at Eliot Congregational Church in Newton where he lived the last 47 years. He was the founder of Powrex Switch Co. of Watertown and ran it until he disbanded it in 1975. During World War II he doubled by working with Raytheon Co. on radar and on the mass production of magnetron tubes as devised by the late great Percy Spencer. In off hours he was a Boy Scout Leader and committee member of Norumbega Boy Scout Council. The Class's sympathy goes to Mrs. Burkholder and the rest of Ted's family.

George M. Holmes Jr. writes from California: "Leading a quiet life here in Paradise (Calif.) since a recent angina attack. Still very much interested in M.I.T. activities and the Class Notes."

See you all in Cambridge next June!—Co-secretaries: **Herbert R. Stewart**, 8 Pilgrim Rd., Waban, MA 02168; **Russell W. Ambach**, 216 St. Paul St., Brookline, MA 02146

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The time has arrived for giving some thoughts to the 60th reunion which is only a year and a half away. Our president, **Jim Howard,** wants to hear from classmates, providing him with suggestions and ideas for reunion activities. Also, he would like to have some volunteers to work on planning and organizing. Jim's address is 3 Locust St., Cambridge, MA 02138. So let's get busy and give Jim a hand.

It is with sorrow that I have to report the passing of **Samuel Glaser** on August 7, 1983 at the Beth Israel Hospital in Boston. Sam was born in Riga, Latvia and was brought to the U.S. by his parents when he was 4. Sam was a widely known architect and credited with introducing the split-level home concept in New England and with being the first to utilize air rights over public highways.

Among his works is the Star Market over the Massachusetts Turnpike in Newtonville, the first construction to use air rights in this country. He often expressed his belief in quality design and construction which would integrate the natural environment with people's living and workplace needs.

His designs include Castle Square, the John F. Kennedy federal building, Sack Cinemas, the Government Center Garage, the original control tower, and the American Airlines hangar at Logan Airport, West Roxbury High School, Cardinal Cushing Chapel and School for Boys in Scituate, Baldpate Hospital in Georgetown, and the synagogues of Congregation B'nai Israel in Woonsocket, R.I. and Temple Shalom in Newton.

Colleagues said Sam was a major force in the use of sculptures and paintings in public places and was a supporter of the Museum of Fine Arts in Boston and the Rose Art Museum of Brandeis University. He also was an active member of the American Institute of Architecture and a 32nd-degree Mason.

Sam leaves his wife, Dorothy (Orlov); two daughters, Constance G. Kantar of Newton and Priscilla Glaser who lives in France; a son, Paul M. of Santa Monica, Calif.; a sister, Vera G. List of Greenwich, Conn., and eight grandchildren.
—**F. Leroy (Doc) Foster,** Secretary, 434 Old Comers Rd., P.O. Box 331, North Chatham, MA 02650

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Writing the class notes this month is a sad duty due to the deaths of a number of our friends and classmates. A newspaper article announces the passing on June 5 of **Stanley P. Sawyer,** professional engineer and secretary of the State Board of

Registration of Professional Engineers of New Hampshire. He had been president of the New Hampshire Society and an active officer of the First Baptist Church of Exeter, N.H. He is survived by a son, Paul S., and two grandsons.

Ralph F. Blake's death on April 15 was noted in the Portland, Maine newspaper. He had attended Columbia University prior to M.I.T. and was a navy veteran of World War I. He had retired in 1967 from the Drew Chemical Co. and is survived by his wife Hazel Leard, two sons, seven grandchildren, and six great-grandchildren.

In the previous issue of the *Review* we mentioned the inability of **Dave Shepard** to attend our 57th reunion due to a health problem, which led to his death a few weeks thereafter on July 10. In the preceding week, on July 4, **Thornton Owen** died, following a heart attack at his summer home. The almost simultaneous loss of these distinguished classmates was a profound shock to all of us. Since both had been very close personal friends as well as active M.I.T. participants with **Jim Killian** during his administration, we felt that it would be appropriate for Jim to write a statement about the significance of their lives which is quoted herewith: "I was shocked and deeply saddened by the deaths of **Thornton Owen** on July 4, **David Shepard** on July 10, and **George Leness** on August 17, all three having brought distinction to our class. When we were undergraduates, Thornton Owen and I worked together on *The Tech*, he as general manager and I as editor. This was the basis of a warm friendship that lasted over the years. When I went to Washington to serve as science advisor to President Eisenhower, Thornton and his wife, Collette, were thoughtful in helping us adjust to the Washington environment, and we visited them both in their Washington home and in their summer place.

"While in Washington, I came to appreciate Thornton's financial leadership in the Washington area. He served as president, board chairman, and director emeritus of the Perpetual American Federal Savings and Loan Association. In this position of leadership he made great contributions to the economy of Greater Washington. He won wide respect for his understanding of the area's poorest downtown neighborhoods, and for his vision, as the *Washington Post* was to say, 'to see a connection between a healthy business economy throughout the region and a stable center city supported with money to buttress new and improved housing.' His achievements as a socially responsible banker were admired and appraised as profoundly influential. I cherished my friendship with him and was proud to be his classmate.

"David Shepard, president of our class, had passed his 80th birthday when he died. His courtly manner and warm personality endeared him to all, and his distinguished career as an engineer, corporate leader, and public servant stirred the admiration and respect of all of us. After receiving his master's degree in chemical engineering, he joined a group of M.I.T. graduates who were revolutionizing Standard Oil of New Jersey's research and development operations in Louisiana, and from the start he held many posts in the United States and abroad in that company and contributed to its growth and corporate leadership.

"He served as a member of the M.I.T. Corporation for 32 years and did virtually everything a Corporation member can do for his alma mater, participating fully in the Institute's governance, in its major fund drives, and in service on the Corporation Executive Committee. To this key committee he had the distinction of being elected five times while serving with four presidents of the Institute. He was active in many alumni committees and programs and in 1976 received the Bronze Beaver Award, the highest recognition of the Alumni Association.

"In 1927 he married Katherine Berney Fisher, who died in 1981. She, too, was greatly beloved by members of the class, and together they attended and presided over most of our class reunions. Members of the class will recall with delight and affection Dave's mastery of the banjo and the mandolin. He performed while a student at M.I.T. and almost always at our reunions. I have special reasons to be deeply moved by Dave's death. He was a friend for more than half a century. At M.I.T.'s centennial celebration in 1961, he served as marshal of the procession, carrying the Institute's great mace. He had also represented the alumni in speaking at my inauguration.

"While rising to the apex of Standard Oil's administration, he served on many important boards, notably the Carnegie Corp., of which he served as chairman of the board for three years and a trustee for 14 years. He also served on the board of the New York Public Library, and he diligently sought funds for its endowment as indeed he did for M.I.T. Much more could be said of this wonderful man, but his classmates have reason to celebrate his remakable career and to feel glad that such a man was in our midst."

George J. Leness died in Southampton, L.I. Hospital after a brief illness. George and I had been close friends at M.I.T., both of us later attending Harvard for our A.B. degrees. **Jim Killian** continued his relations with George as members of the board of directors of the Ingersoll-Rand Co., giving them the opportunity of enjoying their friendship in retirement days. George became president in 1961 and chairman and chief executive in 1966 of Merrill Lynch Pierce Fenner and Smith. He was a life member of the Corporation of M.I.T., founder of a scholarship fund for worthy students taking an active part in intercollegiate athletics, and member of the boards of numerous corporations, as well as other civic activities.

Dave Shepard's family suggests that in lieu of flowers contributions could be made to M.I.T. In response to my question to **Jim Killian** about a memorial to Dave as part of our 60th reunion gift, he pursued the matter with Hugh Darden's office. A fund based upon contributions that Dave had made earlier and gifts received following his death will function as an endowment. Those of you who would like to contribute should send your gifts to the Associate Recording Secretary, Room 4-113, M.I.T., Cambridge, MA 02139. These gifts should be made out to the "Dave A. Shepard, '26 Fund."—**William Meehan,** Secretary, 191 Dorset Rd., Waban, MA 02168

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Reporting this month are excerpts of interesting correspondence between **Bud Cole** and **Sidney Blandford, Jr.** in Denver as follows:

"Dear Sid, First you are going to hear of the influence you have had on my life. Some years ago, the exact number not given for security reasons, we were attending summer school at M.I.T. After lunch together at the beanery on Mass. Ave. you offered to drive me to the Beta House in Brookline, and passed the Boat House on Memorial Drive. As a crewman you couldn't go by without stopping and to introduce me to the sport of rowing. As a novice Coach Haines put me in a wherrie, you were given a beautiful mahogany English shell. The next day we went rowing again. The coach had left on vacation and the attendant seeing me with an experienced oarsman, brought me out the twin of your beautiful shell. I got your signal to keep quiet. I was pushed away from the dock not daring to move a muscle for fear of capsizing. I slowly moved down river where you were waiting to give my first instructions in rowing with a scull. It was a great experience and one I never forgot.

"We went rowing a number of times that summer. Coach Haines returned and blew his top, but softened when he found your tutelage had produced a competent oarsman.

"Years later I had a second opportunity to again take up rowing. I bought a pleasure cruiser for San Francisco waters. Also I bought a pretty little fibre-glass shell—not English—but very suitable for our waters. Rowing has been an exhilarating experience for me and I often think of the casual way it all began. Best regards, Bud Cole."

"Dear Bud, Your memory is better than mine by a great deal. Any research that I did at summer school was unscheduled and not of any academic nature. I am pleased to note that things I taught you were of proper nature and did not mar your character.

"All joking aside, I did think of going to the Reunion last year. I was thinking of asking **Frank Mesker**. We went to our 25th together. His death changed all that. He was a good guy. I cannot walk far without resting due to poor blood supply in my legs. I do keep walking and resting to keep them (active), but I would not go (to the reunion) alone. Frank had a problem, so we would have made a good pair at our 55th.

"Ruth and I had our 50th wedding anniversary last year. Ruth is very tolerant as you can guess. We had four children, two are living and we have eight grandchildren.

"I worked as an engineer and sales engineer for five years. The depression looked foreboding in 1932 so I went to the Univeristy of Colorado at Boulder to take pre-med subjects, then to their medical school and graduated in 1937. I served as residency in surgery at Cleveland and went into the Army in 1941 for four years. Then two years in the South Pacific theatre.

"I came back to Denver and went into private practice. It was 14 years after I quit as an engineer—not as I had planned. I did plastic surgery, but quit in 1973 due to complications of surgery and the ravages of time. (Ed.: Sid is a Fellow in the American College of Surgeons) Retirement without walking ability is no good. I don't recommend it.

"I also wear contact lenses, not from vanity, but due to bilateral cataract surgery. Cataract glasses are horrible. Everything I do takes longer, even puttering. I do go to the Medical School Clinics as a volunteer two to three times a week which occupies some of my time. I don't contribute much because all the young doctors are smarter than I am.

"Thank you again for your letter. Best wishes, Sid Blanford."

"Dear Sid, I enjoyed your good letter of May 14. As for myself, I will start off by relating another experience we have in common. . . ." TO BE CONTINUED IN THE NEXT ISSUE!—**Joseph C. Burley,** Secretary, 5 Hutchinson St., Milton, MA 02186; **Lawrence B. Grew,** Associate Secretary, 21 Yowago Ave., Branford, CT 06405; **Prentiss I. Cole,** Associate Secretary, 2150 Webster St., Palo Alto, CA 94301

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In the weeks immediately following our 55th reunion we received a small flood of notes and letters from classmates. Mostly they were to express thanks and appreciation to the planning committee. We were delighted to receive them, of course, and we thank all of you. Some contained news items and we are happy to share these with you.

Following the five days of events in Cambridge, Ellen and **Dean Batchelder** spent the next two days visiting with Marjorie and **Bill Bendz** in Maine before flying home to California and back to ranch life. . . . **Shikao Ikehara** made good use of his long trip from Japan by spending some time in the U.S. He writes that he is trying to translate a book on the life and work of Norbert Wiener. Already Shikao speaks of coming back for the 60th.

Anne and **George Palo** also took plenty of time (12 days) when they drove home to Knoxville, Tenn. They started with a few days stay at an old inn in Newfane, Vt., then stopped in Lexington, Mass., Providence, R.I., Madison, Conn., Mantua, N.J., and Swarthmore, Pa. At this last stop they were the guests of Gene and **Chuck Topping** for lunch along with **John Melcher**. Chuck was city manager for Swarthmore after he had retired from duPont. From all reports, he did an outstanding job for the city. . . . Since returning home to Fryeburg, Maine, Priscilla and **Roger Haven** have paid a visit to **Jim Tully** who lives in the same town. They report that Jim looked good and was cheerful although he does have health problems. We were sorry to learn that Jim's wife, Susan, had died.

Apparently the class widows enjoyed the reunion thoroughly. They teamed up with others to help Dorothy (Mrs. **Carney**) **Goldberg** with the Country Kitchen snack bar that was the welcome point and social center for all arrivals. Then, of course, they joined in the general program thereafter. Several of them have sent cordial and enthusiastic letters. . . . Judith (Mrs. **Benjamin F.**) **Miller** wrote to say how much it meant to her to join in the occasion with so many of Ben's classmates and friends. . . . Mary (Mrs. **Arthur A.**) **Nichols** expressed her pleasure in having attended. Her busy summer was to be concluded with a visit to England. . . . Josephine (Mrs. **Edward M.**) **Shiepe** told us what pleasure she had experienced at the reunion. She also told of an event that occurred last winter when she was invited, as a special guest, to attend an exhibit of Ed's work at the Polytechnic Institute of New York (where Ed had received his M.A. degree). In Jo's own words: "After a champagne lunch with faculty, I was ushered to the main corridor to see the exhibit. It was splendid. I was overcome with the thrill of viewing a well-earned and deserved recognition! I treasure the many photographs given me of that auspicious occasion." Congratulations, Jo, on this high point of your life and on such an appropriate recognition of Ed's professional work.

The reunion group photograph (in color and panorama) was mailed to all classmates who attended. **George Chatfield** was in charge of the class picture operation and the photographer did an outstanding piece of work. We have had many favorable comments. One of the most hearty notes came from **Ernie Knight** in Raymond, Maine. His letter also tells us that he did some rowing while at the reunion and was amazed to find that most of the rowers on the river were girls. "Revolution!" is what he calls it. Ernie and Louise were planning to attend the annual meet of the Wheelmen (cyclists) at New Haven in August (and more campus dormitory living, this time at Yale). While there they hoped to see Bea and **Harlan Paige** and Louise and **Ev Lester**. . . . We are sorry to learn from **Jim Donovan** that **Ed Walton's** wife, Dodie, has been ill. We all send her our very best wishes.

A letter from **Charlie Worthen** says that the group picture is an amazing production; he further marveled that so many people turned out for the 55th. . . . Writing from Mexico, **Leonardo Siller** comments on the wonderful "spirit of togetherness of the class which made everyone feel at home." . . . Jackie and **Phil Proctor** had an especially long reunion time since it was her 50th at Wheaton in the week preceding his 55th. They returned home tired but very happy.

Ken Clark was unable to be with us in June but received the memorabilia since he had signed up originally. Like others, he was greatly impressed with the picture and only regretted that he had not been there. . . . **Sid Brown** expresses his regrets at having to miss the 55th but promises to be with us for the 60th. He is president of his Auto Association which he says keeps him busy and "away from the saloons." He wishes all classmates well and reminds them that the welcome mat is always out in Palm Beach, Fla. . . . A note from **Orin P. McCarty** says that after 12 years of retirement from General Electric Co. in Pittsfield, Mass., he still feels fine and is active with gardening and bicycle touring. He spent three weeks last February in Sarasota, Fla. with his college roommate, **Gene Boehne**. He says Gene is in good shape, too.

Now, to you all, happy holidays and a very good year ahead!—**Walter J. Smith,** Secretary, 37 Dix St., Winchester, MA 01890

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Phil W. Sayles of Lakeville, Conn., has been retired for 12 years from General Electric and does part-time work from time to time. He has been active in the Rotary Club in his district and plays the piano to open the meetings. He was the recipient of a presidential award for special services with the inscription of "Master Musician" as reported in the *Rotary Bulletin*, July 1, 1983. He also received the Purple Bull award given every year but two since 1951, indicating exceptional service to the club. . . . **Hyman J. Fine** of Norfolk, Va., has sent a note reading, "Many thanks for the birthday card and its very appropriate verse. I am still working three days a week planning water resources development projects and occasionally have articles in A.S.C.E. publications on tidal flood protection measures. My wife Edie and I traveled to Israel which proved to be a fascinating journey. As a member of the organization of engineers and architects there, I receive their technical papers and I find them of great interest. Since my return, I have appeared before various groups and have shown slides taken on the trip which also include Egypt. I manage to get in a few sets of tennis each week and enjoy delivering meals-on-wheels one day a week. Recently, Edie and I celebrated our 50th wedding anniversary."

Seymour Baum and his wife Claire have moved to Jupiter, Fla., where they hope to enjoy the gentle climate and play golf for pleasure rather than trying to qualify for the U.S. and British Opens. . . . When I sent a birthday card last March to **Arnold W. Conti** of Highland Beach, Fla., I enclosed a personal note asking "What are the advantages of living in Florida for persons in our age bracket?" Here are the highlights of his reply. "If Florida is not *the* least, it certainly is *one* of the least expensive states to die in. If you plan to pass on soon, I urge you to make the move quickly, your widow and heirs will be grateful for the move. Allow three to six months for preparation of wills and trust etc. if that is the way you choose to go. Florida has no income tax but it does have a tenth of one percent levy on intangibles, after a deduction of $40,000 for a couple. There is no inheritance tax when you go. There are many types of Florida living: the resort, the retirement or the kind found in most of the large cities. Mary and I chose Jacksonville area because we have easy access to cultural, educational, commercial, and medical facilities and a large inventory of friends accumulated over the years. Florida has a lot going for it, but I urge no one to make the move before exploring it thoroughly. I stay busier than I want to. I sit on two boards, do some "do gooding," fish, golf, help Mary and the Jacksonville Art Museum with their art shows, spend more time with my ophthalmologist than I want to. Best regards to all."

James C. Reddig of Webster, N.Y., writes, "I find myself more involved every month with aviation history buffs and the wonderful kind of idiot fringe that restore and build their own airplanes and flock to the great assemblage at Oshkosh every month. I get down to the National Air and Space Museum as often as I can and I get a great deal of enjoyment digging about their archives. In May, I joined a Smithsonian Tour to all the principal airplane collections and museums in Britain. Lectures at the Royal Aeronautical Society, lunch at the Aero Club, etc. And then on to France and the French Museum and flying displays including a couple of days at the Paris Air Show. The Shuttle just blew their minds over there; not too many realized that the Shuttle could carry a Boeing 747 around! Our hosts everywhere couldn't have been kinder. I got to fly with a Frenchman who had rebuilt a military trainer, circa 1951; he gave me an aerial tour of Fountainbleu and environs. This is about the sixth time I've been around this museum loop in Europe. I never tire of finding lovely old airplanes that I haven't seen before. I hope to join up with any future program that N.A.S.M. organizes. Our fabulous national museum has set new standards, and all these foreign establishments are doing a great job of catching up. Best regards to all."

Ed Roche and his wife Dorothy of Buffalo, N.Y., celebrated their 50th wedding anniversary last year at North Jersey with their children and grandchildren. As part of the grand celebration, they traveled by air to San Francisco, spending four days, visiting places of interest. They took a Parlor Car Bus Tour to Yosemite National Park and down to Los Angeles, stopping at Monterey to visit the world famous Hearst Castle. They spend the Christmas holidays with their daughter Marcia and family at West Springfield, Va., a suburb of Washington.

Received a letter from **Wally Gale** of Melvin Village, N.H., which reads, "For the past two or three years I have not responded to your annual birthday greetings because I have so little to report. However, your friendly messages are appreciated and we all indebted to you for keeping your classmates in touch with one another.

"Joan and I have not been far or done much since my last letter. We are enjoying the beauties of the New Hampshire Lakes region, and overlooking its drawbacks, such as its winters and its remoteness. We see very few classmates up here, although **Eric Bianchi** did arrive on August 7th for a week of golf at Bald Peak C.C. He lost his beloved Katie this spring, after a short illness—which saddened all of us. Eric and Kay were with us for 17 consecutive summers during the fifties and sixties for our Invitational Tournament, and we have wonderful memories.

"Our son Tom arrives today (July 29) from Nairobi, where he has been teaching at the U.S. International University for the past seven years. He is still the peripatetic professor, having taught for four years in Japan, plus shorter stints in Switzerland and England. . . . interspersed with five years of graduate study at Harvard and University of London. He is unmarried but has 'adopted' eighteen young native girls (ages 12-14) whom he is putting through secondary school in Nairobi. In Kenya, the first six years are free for everyone, but tough exams and tuition costs permit only a few students to go on. Of the 365,000 seventh graders taking the exam this year only 20,000 qualified girls could raise the money to continue their education. The others will probably marry at 14 and be old at 20. The government helps the boys but the 'poor but bright' girls drop by the wayside. Tom has organized a Kenya Student Aid Fund which has been given tax-exempt status in this country by I.R.S., but he is having trouble getting it approved by the Kenyan bureaucracy! In the meantime he is doing the best he can on his own.

"Daughter Joanie is still 'emoting' in the world of Boston theater, but she spends weekends and other free time in her house up here in Melvin Village. She is also unmarried, and our only grandchild is our Cavalier King Charles Spaniel, Nicholas, to whom we are devoted. We take him with us on our visits to the Homestead in Hot Springs, Va., as the hotel furnishes dogsitters and room service. The latter consists of the delivery to our room at 4 p.m. each day of a choice of the leftovers from the previous evening's menu in the dining room. All for $1.75!

Nicholas gets similar treatment at the Ritz-Carlton in Boston, although the Chateaubriand and Polet Provence are replaced by Ken-L Ration. The dogsitter is usually an off-duty maid at the hotel—one of whom exclaimed when we returned to our room and found them both watching television: I hate TV but Nicky loves Channel 2. And so it goes. Best regards to all."

A note from **Eric A. Bianchi** of Tequesta,. Fla., reads, "Thank you for your note of sympathy. Yes, Kay left me on May 22 from cancer which was not diagnosed until March 30. Fortunately, she did not suffer long. We had almost 52 years of happy married life together and I have many happy memories."

Dorothy (Mrs. **Marshall S.) David** of West Dennis, Mass., a charter member of our class Widows Program, has sent me a note as follows, "After reading the class notes in the *Technology Review*, which came last week, it occured to me that perhaps you did not know that Professor **Clifford P. Kitteredge** lost his wife about a year ago. In the letter he wrote to me, he said Jane died almost instantly from a massive heart attack while preparing dinner. He went to California to be with his children for a while, and I haven't heard from him since. I was also very sorry to learn that Mary Gardner (wife of **Jerry Gardner**) had passed away. This is a difficult time for so many of us. Ruth (Mrs. **James) Fahey** also a charter member of the Widows Program has asked me to room with her at the 55th

Reunion. I am still undecided as it is very difficult for me to go places where Marshall and I always went together, though everyone tells me that I must get over feeling that way. Unfortunately, it was at Chatham Bars Inn that Marshall had his attack, even though he lived two more years, mostly in bed. I do hope all is well with you and I will try to attend next June, if I can. Best regards."

I regret to announce the death of two members of our class, **Daniel J. O'Connell** of Holyoke, Mass., on July 14, 1983; and **John Saloma**, formerly of Weymouth, Mass. I received a note from **Paul F. Donahue** of Nahant, Mass. who sent me the published obituary of Dan O'Connell, stating that he had been ill for almost a year. He was president of a large construction firm, established by his grandfather, known as Daniel J. O'Connell and Sons, based in Holyoke, Mass., one of the largest construction firms in New England which has built many notable buildings, bridges, college campuses across the state. David Bartley, former Massachusetts Speaker of the House, now president of the Holyoke Community College, built by O'Connell, said that "he was just a giant of a businessman who chose to remain loyal to his family, his church, to his heritage, and to the city of Holyoke." A few years ago, he was chosen as "the Man of the Year" by the Holyoke Chamber of Commerce. He is survived by his wife, Lillian and two sons.

John Saloma was a specialist in American politics. He was co-chairman of a group who founded the Ripon Society, a moderate Republican research and policy organization. Aside from his M.I.T. affiliation, he held a master's degree from Harvard. He also was a Fulbright scholar at the London School of Economics. He was a staff associate of John F. Kennedy Institute of Politics at Harvard and has been a Congressional Fellow of the American Political Science Association with the late Sen. Leverett Saltonstall of Massachusetts. In 1966, he was a research director in the first senatorial campaign of Edward W. Brooke of Massachusetts. In 1969, he was selected as one of "Ten Outstanding Young Men" by the U.S. Junior Chamber of Commerce.—**Karnig S. Dinjian**, Secretary, P.O. Box 83, Arlington, MA 02174

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This month's longest-distance report comes from **Elias (Jumbo) Klein**. After graduating in course X-A, Elias initially worked for Steel Co. of Canada, but within a few years returned to his native South Africa, where he spent most of his career with the South American Iron and Steel Corp. He retired in 1968 as assistant general manager (technical) and thereafter did consulting work for Vanderoyl Engineering and Dunwart Iron and Steel Co. He and his wife Trudy live in Killarney, a suburb of Johannesburg. . . . **Wes Wedemeyer** has now completed three assignments with the International Executive Service Corps, a volunteer organization that provides U.S. consultants to foreign companies. His work with developers of a shopping center in Colombia and a satellite city 30 miles from Buenos Aires were described in the August 1981 Class Notes. More recently, he spent several months in Portugal working with the developer of a resort area to accommodate 30,000 people on a peninsula located about 25 miles west of Lisbon facing the Rio Sado and the Atlantic Ocean. Wes says the best way to express his feelings about this volunteer work is "to say that it is an experience that money can't buy." . . . **Haskell Small** is still involved with a considerable number of cultural and recreational organizations in Washington, D.C. He is particularly active at the moment with the U.S.O. as chairman of a committee to select a site for a U.S.O.-Bob Hope Center. He is also a member of the Opera and Ballet Boards and vice-president of the "Paul Hill Chorale."

Paul Kimberlein is living in Pearce, Ariz., and like me, attends meetings of the M.I.T. Club of Tucson. However, it has been some time since our paths crossed, because he normally goes to luncheon meetings, and when we are in Green Valley during the winter I find it more convenient to go to evening meetings. . . . We have at hand recent communications from three classmates who are still gainfully employed, two of them (**Sig Linderoth** and **Jack Latham**) in the field of medical technology. Sig's semi-retirement activity, as previously reported, is designing hyperbaric chambers. He is currently working on the design of two large medical hyperbaric oxygen treatment facilities and is also consulting with a medical center in Danville, Pa. . . . Several years ago **Jack Latham** founded Haemonetics, Inc., which has since become a sizable manufacturer of blood-processing equipment with a listing on the O.T.C. market. Recently Jack negotiated a merger agreement with American Hospital Supply Co. under which Haemonetics will become a division of A.H.S. and its stockholders will receive A.H.S. shares. As an incident of the merger Jack will have an employment contract for two years and hopes to continue his association with the enterprise beyond the initial contract term. Jack's interest is primarily in new product development and he thinks some of his ideas may tie in with existing A.H.S. product lines. The Lathams are just completing the building of a new house, adjacent to their present house and particularly designed for retirement living, with all primary living facilities on one level. It is designed to minimize maintenance and "has just about every convenience you can imagine." Jack hopes "classmates will come to see us when visiting Boston." . . . **Joe Harrington** is still working about 30 hours a week, consulting on manufacturing technology. Those he works for include his old firm Arthur D. Little, Air Force Systems Command, I.B.M., and various law firms who need an expert witness in patent infringement and antitrust cases. He has completed the manuscript of his second book, *Understanding Manufacturing*, which deals with the problems of maximizing productivity through the use of computer-integrated manufacturing. It will be published by Marcel-Dekker, Inc., late this year. Last May, Joe attended a meeting of the Cardinal and Gray Society, an organization sponsored by the Alumni Association and comprising alumni who have been out of school more than 50 years and live near Boston. They meet once a year at Endicott House, a large mansion in Dedham owned by M.I.T., and have dinner, after which a faculty member speaks on a subject of interest to the group. Classmates attending this year included, in addition to Alene and Joe, Grace and **Elmer Burling,** Eva and **Alfred Carideo,** Edith and **Bill Harris** and Ruth and **Jack Latham**.—**Gordon K. Lister,** Secretary, 294-B Heritage Village, Southbury, CT 06488

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Ken Germeshausen lived up to his promise of our mini-reunion and wrote the following letter: "The cruise to Alaska was fabulous. Everything was up to expectations and on schedule; no luggage or passengers were lost. All 13 classmates and wives attending were enthusiastic and wanted to know what we could do for our next reunion. One of the benefits most talked about was that it gave us a chance to talk to each of our classmates in depth and find out what they had been doing for the last 53 years. As for myself, after graduation I joined **Doc Edgerton** in a consulting partnership to use high-speed photography and stroboscopic techniques for the solution of industrial problems; business was good, so **Grier** joined us in 1934. I was made a research associate at M.I.T. without stipend, a position I still hold emeritus. When the war came we each went our separate ways. I joined the Radiation Lab and later became involved with nuclear weapons development at Los Alamos. In 1947, we got together again to found E.G.&G., Inc. where I was successively treasurer, president and chairman. I'm now retired as chairman but I'm still a consultant to E.G.&G. and a member of the Business Development Committee. E.G.&G. is now in the Fortune 500 with sales of over 800×10^6. At M.I.T., I am a lifetime member emeritus of the Corporation and member of the Council for the Arts. In addition, I am a director of several companies, a member of the corporation of the Franklin Pierce Law School, and active in town affairs. So you can see, I am reasonably busy.

A welcome note from **Fred Elser** says, "For Class Notes: the Elser's Reunion in Pleasanton, Calif., June, 1983. We stayed at a Howard Johnson's Inn, and all was well until three nights before we left, when someone cut a hole in our first floor screen (off pool patio) and dumped out all the folding money in Mardy's purse. We were sleeping at the time. No physical harm to us, thank goodness, nor even any credit cards purloined. Could have been much worse (say, if we had awakened and got clobbered!). Anyway, we had children and grandchildren from both coasts for a couple of days, and other relatives and old friends. Not bad. No hamming, though did visit "World-radio" in Sacramento."

A letter from **Randy Binner** mentions, "It seems more than two months since we had that very enjoyable cruise. It has been an unusually hot summer here. I know you are accustomed to the tropics, but we are not. We visited Evelyn and **Howard Richardson** last Wednesday and Thursday and relived the trip for them. I am sure we made them feel sorry that they had not been along. They were interested in each person on the trip as well as the places we visited. They expressed interest in the next mini-reunion in Egypt or Greece, where they have already visited. Howard is still on the board of directors of several companies, although he says he has cut back from his former full activities. They both seem to be as well as can be, considering that it has been some time since 1931."

A note and announcement from **Myrle Meader Perkins** tells of his marriage on July 16, 1983, at the University Baptist Church, Santa Cruz, Calif. Emily Dalton Anderson, Myrle's wife, was born in Penacook, N.H., and educated at Colby College. She also spent a year at Mount Allison Ladies College in New Brunswick, followed by studies in dietetics at the University of New Hampshire. A separate note from Myrle tells how much they enjoyed the Alaskan cruise and are looking foward "to the next expedition of the '31ers." . . . We have written to some classmates from whom we haven't heard for years, asking to be brought up to date on their activities, but the results haven't been very encouraging. If any of you would like to have information regarding any particular classmate, please let us known and we'll do our best to contact him or her.—**Edwin S. Worden,** Secretary, P.O. Box 1241, Mount Dora, FL 32757; **John R. Swanson,** Assistant Secretary, 27 George St., Newton, MA 02158; **Ben Steverman,** Assistant Secretary, 3 Pawtucket Rd., Plymouth, MA 02360

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We have received information that **John Leslie**, 73, died in July of heart problems following a two-day illness. He served for 20 years with the U.S. Corps of Engineers, retiring in 1976 as Chief of New England Division. He supervised millions of dollars of civil and military projects. He was active in many professional and civic organizations. He leaves his wife, Betty, two sons, and a daughter.

John Brown was a high school friend of John Leslie. Incidentally, John Brown has just returned from a two-week vacation in Rome and Athens. Seeing all this antiquity he says makes one stop and think.

Bob Semple writes us the sad news that his wife Isabelle passed away in early August. We recall that she attended the 50th Class Reunion but was not well. She improved somewhat in the following winter and seemed in fine shape when Bob and Isabelle celebrated their 50th anniversary at their Virginia home with their children. She died a merciful death by an unanticipated heart failure while at their fishing club.

Bob writes "as for me, I have plenty to do with lots of old friends around the country. So with a pleasant house and with a devoted housekeeper of

30 years I will do o.k. Still, a central lifetime of associations has gone and will be missed."

I have just received word that **Jack Kelman** died about a year ago. When details arrive, I will forward them to you.

My backlog of news about our classmates is exhausted. I have served as Secretary for several years and have not missed a publication. If you like to see these notes appear I BESEECH each and everyone of you to grab a pen and write me immediately. Anything will do—major or minor, an activity or a thought—but write something, now!—**Melvin Castleman**, Secretary, 163 Beach Bluff Ave., Swampscott, MA 01907

33

By way of **Clarence Westaway** comes a letter from **Don Fink** written in midsummer. He had been in a hospital for two weeks and was making a good recovery from an "attack" of undefined nature. He says he must slow down, as shouldn't we all. He continues editorial work in the field of TV. . . . News this month from a previously unreported member: **Clint Backus** of naval architecture. In recent years he has engaged in real estate promotion and house building and sales in the Los Angeles area. He sells houses and sails boats. Makes no reports of seeing any '33ers. . . . **Ernesto de Sola** writes that with the troubles in El Salvador he moved to Guatemala in midsummer. He practiced architecture and building development most successfully in the former city for many years.

George Stoll did an excellent job treasuring the reunion. Thanks George. . . . **Warren Henderson** spent the summer at Exeter, N.H. By now he is probably back in Florida. . . . Jermain and **Jack Andrews** spent three weeks in Ontario where things were cool and quiet before returning to Jersey via Montreal, where their recently married daughter Gwen lives. . . . **Walt Duncan,** who lives in the Philadelphia area, attended the campus reunion events but didn't get to the Cape. This was the year to attend Janet's reunion at Wellesley.

From somewhere came a clipping about **Ben Olken,** who lives in Cambridge. When '33 graduated there was little for architects to do, and Ben opened a bicycle shop. Through the 50 years he became one of the major bike dealers and wholesalers and is about to retire. . . . A little note from **Archibald Callender,** addressed to "Jim" and forwarded by him, says, "After Vail, Santa Fe, and Scottsdale, Ariz., all the money in Wall Street couldn't get me back." We don't have an address. Where are you, Arch?

The class pictures came out good, it is reported. How did **Mal Mayer's** TV movies of the class at Chatham Bars come out? . . . That's all for now. Drop me a note.—**Beaumert Whitton,** Cottage 112, Sharon Towers, 5150 Sharon Rd., Charlotte, NC 28210

34 50th Reunion

There was nothing new that came recently, either directly or from the *Review* office but I did find two Fund notes that had been overlooked in the past.

One is from **John Newbegin** who says, "I am back from the hospital after a mild coronary. A few weeks of healing and I'll be able to climb mountains; also can put down the new floor at our place on Lake Champlain. Looking forward to our 50th. Enjoying retirement, especially in the summers."

The other note came from **David Tashjian**. He writes, "Retired from Lockheed Missiles and Space Co., Sunnyvale, Calif., in 1976. Since then have spent nearly 15 percent of my time in England researching for a possible book. Have written and published two non-technical books and edited a third. Enjoy the M.I.T. at the POPS here in San Francisco."

And now I hope I may be allowed a personal word or two about what I have to report so increasingly often. In the October issue I mentioned the loss of Ray Jewett's wife Olga who had been a classmate of my wife, Jane, at Simmons. Sad to relate, I have just joined him as Jane died suddenly on August 10. There was no prior illness; she suffered a cerebal hemorrhage and fortunately went instantly and painlessly. I'm grateful that we were able to take and enjoy the European trip I wrote about last issue, as well as some other shorter ones. It's the kind of passing we both wanted, but I know that when I have to report future losses in the class my own condolences will come from a far different set of feelings than in the past.—**Robert M. Franklin**, Secretary, P.O. Box 1147 (620 Satucket Rd.), Brewster, MA 02631; **George G. Bull**, Assistant Secretary, 4601 N. Park Ave., Apt. 711, Chevy Chase, MD 20815

35

I wanted to start right off with these notes and give you the last half of **Walter Stockmayer**'s letter. "Contact with classmates has been meager since our 45th Reunion. I did have some correspondence with **Howard Mason** (Course V) over 2 years ago, and visited Selma and **Leo Epstein** in San Francisco in 1982.

"Chamber music is still a big thing with me, and I play whenever I get a chance. There is a local chance to play amateur concerts, and in most years some friends and I have managed to work up something; we have done all three Brahms piano quartets, the two of Mozart, and the first Faure, also Brahms, Elgar and Borodin quintets and several trios. My technique gets worse, but I get better at faking. A different musical business has occurred at Polymer chemistry meetings: a Dutch friend, Ron Koningsveld, has composed a six-part suite for two pianos on macromolecular themes, and we have performed this Polymer Music in a number of places, including Leiden, Helsinki, Freiburg, Akron, Amherst and (this coming Sept.) Bucharest. It's getting so I don't know whether I am invited to these meeting for my science or for my second-piano part.

"Barney Vonnegut, '36, was over for a visit two weeks ago, and we shared lots of recollections of our old teachers in Building 6. From far away in time we now realize how dedicated and skillful many of them were. If any of them are still around in 1985 we ought to invite them to something of our reunion for sure.

"We now have five grandchildren ranging from one to 14 years in age. Younger son Hugh works at the Brattle Book Shop, 25 West St. in Boston, and would be delighted to see you or other '35ers there." It was great to hear from you.

Les Brook writes: "We're fine and last week had an enjoyable three-day holiday in the northern Georgia-Tennessee mountains before the rains drove us back home. There's some beautiful country down here. We spent a half day at the Chickamauga battlefield, very interesting yet sobering, where 36,000 died. I'm still battling the weeds and bugs on my quarter acre-plus vegetable garden. It's a lot of work but very satisfying and the pounds are off that I put on last winter when I couldn't do much outside. About a month ago while hoeing, I picked up an arrow-head. Now I have about eight of them and also several pieces of pottery all of which I find very exciting. I am trying to find someone who may know something about Indian history in this area. I may be gardening on an old Cherokee or Etowah Indian camp ground."

Dexter Clough's letter from his home in Bangor, Maine, was written in late May. "I continue as President of the New England Opthalmological Society, but have somewhat of a break until July 16 when the Executive Committee meets at the Narragansett Club in Rhode Island. During the 1982-1983 season we've ironed out the programs for the 1983-1984 season through the efforts of the Program Committee. This is for a seven-day meeting in Boston. Besides speakers selected from Opthalmologists from throughout New England on themes separate for each meeting, two or three ultra specialists from around the country are pulled in to speak. The specialists are always surprised to see the large size of the audience. There are 500 members in the N.E.O.S. and each meeting is well-attended mainly because the best teachers are picked for each subject. It saves a lot of reading to keep abreast of developments in eye surgery and the science of eye diseases."

The last weekend in July I joined in the annual golf weekend at the Algonquin in St. Andrews, New Brunswick, organized by Dexter and his wife, Frances. There were 13 of us at one point. The weather was good with lots of golf and there was lobster in one form or other at every meal except breakfast. Best of all the company was very compatible and we had a great time. Now I can say I've played at St. Andrews! I have moved to Nashua, N.H., and am only ten minutes from the office and plant of our new company. I still drive to Boston on Tuesdays and Thursdays to finish a consulting job.

I regret to report to you the deaths of two more of our classmates: **George R. Forsburg** died August 7th after a long illness. He had worked at the General Dynamics Shipyard in Quincy for 38 years and retired in 1976. **William H. Bagley, Jr.** died August 20th in Detroit and has lived in Birmingham for 27 years.—**Allan Q. Mowatt**, Secretary, 39 Congress St. Apt. #5, Nashua, NH 03062

36

By the time you read these notes our mini-reunion will have come and gone. More on that at a later date. Everyone seems to be healthy, in so far as I know. **Gerard Chapman** and **Hib Summersgill** again ushered at Tanglewood this past summer. Mary and **Fred Assmann** toured Greece in the early fall, and your secretary went camping on Mt. Desert Island with daughter Martha right after Labor Day. This is all the news I have. Please write and let me know how you are doing.—**Alice H. Kimball,** Secretary, P.O. Box 31, West Harford, CT 06091

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John Fellouris was recently elected a director of the Luzo Bank & Trust Co. . . . **Walter S. Wojtczak**, 73 Van Buren Ave., Hartford, Conn., is still working as senior vice president for Standard Builder Inc. in Hartford, Conn. June's main interests are getting him to retire, golfing and her grandchildren. Wally writes "nothing new or different except for the Morgan Award for my activities (about 30 years) on the Educational Council. Do plan to retire in 1984 and split our time between Florida and New Hampshire. Listed in phonebook in Sarasota, Fla. and Newbury, N.H. Still interested in tennis and photography."

Leslie A. Johnson, Box 2371, Sanford, NC 27330, retired April, 1980 from Cornell-Dubilier Electric, as vice president and plant manager. He is United Fund director and he enjoys golf and fishing. His travels have taken him to Hawaii, Japan, Taiwan, Hong Kong, Great Britain, France and Italy. He says if he is still active he will attend the 50th Reunion in 1987. . . . **G. Richard Young**, 1 Cardinal House, Hammersmith Rd., Newport, R.I., wrote in April that he was leaving for South Germany, Austria and Switzerland and would be away for three weeks. His main interests are cabinet making, watercolor, golf and computers and his wife's interests are organ playing, gardening, travel and grandchildren named Matt, Becky, Elizabeth and Katie. Dick writes "50th Reunion plans started. Meanwhile I hope to get a mini-reunion together for probably late 1983 or 1984 for those in New England and New York. Some other areas could do the same." . . . **John B. Nugent** of Braintree Hill, P.O. Box 8, Braintree, Vt., called Bob Thorson to say he still enjoys living in Vermont and is doing well. The *Technology Review* May/June printed an article saying he received his Ph.D. in October 1982, and this was in error.—**Lester M. Klashman**, Assistant Secretary, 289 Elm St., Apt. 71, Medford, MA 02155; **Robert H. Thorson**, Secretary, 506 Riverside Ave., Medford, MA 02155

40

Very little news to report this time, since material for this publication must be in before the end of August. Summer vacations, etc., probably account for the dearth of material . . . I hope!

Ed Bernard, our class treasurer, informs me that he and Jeanne have completed preparations for mailing of 1983/84 invoices for class dues. These will be mailed the last week in September. There are now 714 class members listed. If you don't receive a notice, contact Ed or send your check to **Edgar Bernard,** 57 Winn St., Belmont, MA 02178.

A press release from Woods Hole Oceanographic Institution, Woods Hole, Mass., covers information on trustees and corporation members elected at their annual meeting. **W. H. Krome George** was reelected to the corporation. He retired recently as chief executive officer of Aluminum Co. of America, remaining as director and chairman of the executive committee.

That's all the news for now . . . please make a little and send it this way!—**Donald R. Erb,** Secretary, 10 Sherbrooke Dr., Dover MA, 02030, (617) 785-0540

39 45th Reunion

Mary and **Jim Barton** are starting a one-month trip to the east coast and Europe. After returning to their lakeshore home in Seattle, Jim plans to retire. After 32-plus years with Boeing, Jim may devote more time to his *n*th reelected term as mayor of Hunts Point. If Jim does that and spends more time around the house, will the lovely Mary extend her *n*th reelected term as mayor of their menage?. . . **Lew Orrell** is retired and divides his time between his Los Angeles home and what he calls a small ranch near Borrego, Calif. At the ranch, Lew's specialty is raising grapefruit and pomegranate. The taste of fruit is best when it is tree-ripened, and harvested at just the right moment of maturity—see Lew for details. Lew asked my suggestion for a barbershop quartet to entertain a business group he chairs, and I was pleased to learn about his interest in barbershop harmony. **John Alexander** and I were active members of SPEBSQSA for some years. **Ernie Kaswell,** John and I also, have experience playing tuba. Any classmates having musical aptitudes (including playing tissue paper over a comb) are encouraged to write **Aaraon White,** 117 Varick Rd., Waban, MA 02168, because three tubas and one or two voices do not constitute a balanced ensemble. Aaron has unusual knowhow about the big bands and all things musical. If he becomes suitably stimulated, and if there are enough volunteers, Aaron might consent to organize and direct a more-or-less balanced group which could make its debut at Reunion. Wouldn't you concur that the possibilities are unlimited?—**Hal Seykota,** Secretary, 1603 Calle de Primra, La Jolla, CA 92037

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Lewis D. Fykse writes that he and Penny have two children, Karen Olsen with two daughters living in Spring, Texas, and L. Dean Fykse, Jr., married, living in Medford Lakes, N.J. Lew is still a manufacturer's representative, selling life safety equipment and energy management systems in four states. He recently enjoyed having lunch in New York City with Ruthie and **A. Hoad Mitchel** who were on their way to England and Scotland to celebrate their 40th anniversary. They have four sons (three with MBA's, one at Harvard, none at M.I.T.) and seven granchildren. Both are fine; Hoad is still working in his own businesses, but is tapering off slowly. . . . **Malcolm J. Abzug** writes, "Professor Otto C. Koppen got me interested in aircraft stability and control at M.I.T., and I've made that my career. I worked for Douglas Aircraft and TRW Systems until 1972, then retired partially. I consult now for a number of firms and also teach at the University of Southern California as an adjunct Professor. What

Lloyd Bergeson, '38, president of Wind Ship Development Corp., Norwell, Mass., demonstrates the spins'l, his latest device to harness wind power and save ships fuel.

Spin Sailing

"It's a sail just like yours!" Lloyd Bergeson, '38, calls to the curious, camera-faced passers-by, as we maneuver through Newport (R.I.) Harbor.

The object attracting so much attention is a 24-foot rotating aluminum cylinder mounted on the front of our boat *Tracker* (owned by David Frantz, '47). It propels the craft at 6 knots in a 15-knot breeeze with the engine completely shut down. Comparable to 700 square feet of conventional sail, the spins'l is the newest sail design by Bergeson.

It operates on the principle of the Magnus Effect, the same principle that enables baseball pitchers to throw curve balls. Wind flowing over the rotating cylinder changes the pressure distribution around the cylinder, and the combination of high- and low-pressure regions creates a significant upward lift force, propelling the boat forward.

The rotational speed of the cylinder is maintained at a constant multiple of the wind speed for optimum performance. The vessel is tacked simply by reversing the direction of rotation. Thus, no additional crew and little if any on-board maintenance is required, says Bergeson. He estimates that the spins'l used in concert with the engine could save 20 to 30 percent of a vessel's fuel bill.

Bergeson's Wind Ship Corp. has also developed two other sail devices—a soft sail that furls up on the mast by remote control from the bridge and a rigid sail (like an airplane wing standing on end) that can be released to feather in the wind. The first type was fitted on a 3,000-ton freighter, the m/v *Mini Lace,* in August 1981 and had saved over 24 percent of its fuel costs after the first year in operation—$57,200. The wing sail, appropriate for ships of all sizes, will be tested on a U.S. Navy vessel.

If 20 percent of the world's shipping fleet used sail-assist devices, the yearly savings would be about 91 million barrels of oil or $2.6 billion, says Bergeson.—*Sandra Knight*

do I teach? Stability and Control, of course. "I'm married, and have two sons and two grandsons. I have managed to stay in touch with a few of our classmates. I see **Bill Lamar,** of Dayton, Ohio, frequently; we both consult for an agency of the U.S. Air Force on a research plane project. I also try to stay in touch with West Coast classmates **Frank S. Mayer, Ray C. Fernandez, Ray Bessy,** and **Bob W. Blake**. I took up flying when I retired in 1972. I earned the soaring FAI Silver C award and have made two flights above 25,000 feet in mountain wave conditions. I recently got an instrument rating. I'll try for the 45th reunion."

Zhou-Xing-Yan was one of my best friends during student days, when he called himself **Norman C.Y. Chow**. When I went to China, I called the Alumni office, and they could not help me locate him. At various times I talked to **Alfred Wu, I.M. Pei,** and **Jimmy Mar**; they remembered Norman but had no address for me. At our 40th Reunion I asked **Zhi-Fang-Li,** who had come all the way from Peking, and he told me that Norman worked for him. Norman writes, "Though it has been a long time since we were at M.I.T., I can still remember as if it is today, your sandy hair, your tall features, gentle talks with a bit of European-style humor, and the dinners we had together drinking French wine—the good old days! Well, as for me, I came back in 1946, after graduating from Cornell and working for Bendix for three years. I have been working at the First Ministry of Machine Building of the Chinese government. The most delightful news I want to tell you is about my granddaughter, only 1 1/2 years old, a little angel with dark brown, curly hair (rather rare among Chinese); she is not only cute but clever, charming, lovable—and all the nice words I can think of won't be exaggerative." Norman is retiring next year and is hoping to visit the U.S. then. His daughter is presently in Chicago studying dentistry.

I am sorry to report that **Don Ackerman** died April 20, 1983.—**J.E. Dietzgen,** Secretary, Box 790, Cotuit, MA 02635

42

Summer doldrums are still upon us as far as class news is concerned at this writing in late August. All of you get some news in here, please!

Bit of really good news: **Floyd Lyon** married a lovely reddish-blonde, her name is Christina, she was living in one of the old houses which Floyd had restored in Roslyn, N.Y. She and Floyd are still living there (guess he pays rent to himself) till they decide where they will put down new permanent roots. Our congratulations and very best wishes to them both.

One retirement: **Bill Denhard** retired on August 1 from his position as head of the Air Force Programs Department of Draper Laboratory. He headed the Inertial Gyro Group of the old Instrumentation Laboratory for 20 years and became head of the Air Force Programs Department when the Lab was divested from M.I.T. Now Bill can spend more of his time working as Treasurer of the Class.—**Ken Rosett,** Secretary, 191 Albemarle Rd., White Plains, NY 10605

43

There being no personal news this month, I shall devote the entire class notes to items from the 40th Reunion.

The preliminary fun and games included a Thursday lunch at the Faculty Club. From that vantage point the groves of academe seem not at all shabby. By virtue of our 40-year status, Tech Night at the Pops found us seated in front of the transverse aisle in Symphony Hall. Between us and the stage were only a few 45-year alumni and the red-coated phalanx of the 50-year and older classes. Growing less young does bring a few privileges.

After the Friday morning formalities, we headed for Falmouth and the highly-touted Cape Codder Hotel. On arrival we learned that the hotel consists of two sections: the refurbished "Old Original" hotel and a much more recent structure disparagingly referred to as the Ramada. Room assignments were by lot, and at first, those getting space in picturesque Old Original were thought to be in luck. Later, however, the perception changed. All the rooms in the Ramada overlooked the beach and ocean; about one-third of those in Old Original did not. At the Ramada there were the usual motel amenities; several occupants of Old Original had to look for them down the hall. Also, some early-to-bedders in Old Original discovered they were directly above the orchestra, whose contract required playing until 2 a.m. In spite of these potential problems, however, there were few complaints, and everyone seemed determined to enjoy the many good features.

On Saturday morning there was the guided tour of the Woods Hole Oceanographic Institute, arranged by **Ken Wadleigh**. Everyone who went on this tour came back very impressed and full of praise for what they had seen. Later in the afternoon the tennis players got a chance to exercise. **Warren Fuchs** had the best deal. He lay in the shade at the sidelines, waving languidly while his wife **Sara** and her cohorts (**Mrs. Frank Dibble** and **Mrs. Clinton Kemp**) cleaned up on their male opponents. Our excuse is that the girls had the advantage of youthful energy, agility and skill, while all we had going for us was trickery and deceit.

The evening hours were given over to the class cocktail party, the traditional class dinner, and dancing to "our kind of music." At this time we also saw the results of **Jim McDonough**'s great efforts with the Reunion Questionnaire. The charts and tabulations are much too voluminous to be reproduced here, but a few excerpts might be in order. We received 192 responses from 452 queries. This compares with 153/599 in 1968, and 379/942 in 1958. Courses II, VI, X, and XV sent 28-31 responses in each. Some statistics: 73 percent have had military service; 52 percent are working in their original academic fields; 175 are married, one "single," four divorced, five widowed; there are 278 sons, 302 daughters; political affiliations are 21 Democrats, 120 Republicans, 42 Independents; mean salary is $59,000; mean weight in 175 pounds (in 1943, 156 lbs.).

Sunday morning **Charlies Coles** sponsored a lifesaving attitude adjustment session at his beach-front house, after which we tied into the sumptuous Cape Cod Clambake. That afternoon was goodbye time, with classmates departing in ones, twos and small groups. By nightfall a memory was all that was left of our 40th Reunion. But stay tuned as we begin to crank up for the 50th.

As of this writing, Tulsa has enjoyed 20 successive days of 100°-plus temperature. Merry Christmas, already!—**Bob Rorschach,** Secretary, 2544 S. Norfolk, Tulsa, OK 74114

44 40th Reunion

Greetings of the season! Happy Thanksgiving, Happy Hanukkah, Merry Christmas, and Happy New Year. Your reunion committee hopes you are using the holiday season to talk with classmates in your area about attending our 40th in Cambridge and Newport, June 7-13, 1984.

Last August, **Andy Corry,** chairman of our 40th reunion, conducted a meeting at the home of Ruth and **Norm Sebell**. Also attending were Marguerite and **Ed Ahlberg,** Jane and **Lou Demarkles,** Janice Kispert, **Peter Matthews, Melissa Teixeira** and guest, Edna and **Stan Warshaw,** and Doris and **Chet Woodworth**. Duties were assigned to the chairman of the various committees, and time was spent on what questions to include in the reunion handbook.—**Melissa Teixeira,** Secretary, 92 Webster Park, West Newton, MA 02165

46

Well, here it is deadline day again, the summer almost expired, and I just returned from a week of trail building and climbing in the "Collegiate Range," a bunch of 14,000 foot peaks with names like Princeton, Harvard, Yale (but no M.I.T., can you imagine) west of Leadville, Colo. Very invigorating. Anyhow, I was just about to kiss off this report for lack of interest when a nice letter arrived from **Max Daggert**, a war-delayed XVIer who graduated in the September class. Max, who presently dwells in Dallas, writes the following:

"After working as a manufacturer's representative for 20-plus years, I've joined with my Houston Associate to found Pace Instruments Corp. to manufacture pressure transducers. We continue to sell instrumentation manufactured by others, acting as their sales offices for Texas and Oklahoma.

"A strong avocation is writing which I've pursued for many years. Currently, I'm finishing work as co-author of *Bilingual Skills for Commerce and Industry*, English and Spanish, which will be published this fall by South-Western, Cincinnati. I've also finished my first novel, *Low Sky, High Sky*, begun in the late seventies, which will be published by the Priority Press, Dallas, early in 1984. A pre-publication offer for the latter is available by writing: Priority Press, P.O. Box 30152, Dallas, TX 75230."

As an "unpublished author" myself, I'm envious. Thanks, Max, and go get 'em! As for the rest of you critters. . . . Write soon!—**Jim Ray,** Secretary, 2520 S. Ivanhoe Pl., Denver, CO 80222

47

This month, given a dearth of mail, I'll bring you up to date a bit on some of the changes around Cambridge. I bike out the Boston side of the river and back on the Cambridge side almost every day (though I can't be sure I'll still be doing it in November, when you read this).

A most recent puzzle on the Charles River embankment is the mystery of the dying ducks which have been picked up by the M.D.C. This morning (Labor Day) I saw only one group of perhaps a dozen in the whole length of the lagoon area. There was an oily scum on the surface of the water, but the true source of the scourge is not yet identified. Today I hope I was just up earlier than they. . . . Buses look strange on Memorial Drive. With the Mass. Ave. Bridge closed to buses and trucks, the bus detour includes part of the Drive. Traffic on the bridge is limited to one lane each way for the rest of us. Perhaps they will engage some M.I.T. people to redesign and rebuild the old thing (it pre-dates M.I.T. in Cambridge) and then rename it.

Noticeable above M.I.T., seemingly taller than the Green building, with the end of its plumb line over the President's house, is the crane working on the new I.M. Pei-designed Arts and Media Technology building on Ames Street. Members of adjacent classes are changing the look of the river bank. George Macomber, '48, who would have been in our class but for the war, has completed the Saddlebrook Building in Riverfront Office Park on the river end of Kendall Square, and the rebuilding of the burned Mt. Vernon Church at the Boston end of the Mass. Ave. bridge (into condominiums). The new addition to the Hotel Sonesta (Roger Sonnabend, '46) being built by Vince Vappi, '48, will at least double its size. The Sonesta, Arts and Media building, the new Whitehead Institute, and the entire Boston Properties development at Kendall Square were made possible by the efforts of **Harl Aldrich** and his firm, Haley and Aldrich, Geotechnical Engineers. They know more about what underlies Boston and environs than any other mortals and are involved in most of the more intriguing projects around here, including the third harbor tunnel and the M.B.T.A. Red Line Extension. From "Earth Works," the Haley and Aldrich newsletter: "The new Porter Square Red Line station has a 70-ft. wide by 600-ft. long chamber totally mined in jointed Cambridge Argillite bedrock. Construction was preceded by extensive and sophisticated rock explorations. A full-length pilot tunnel was mined to investigate the nature of the rock. The new Davis Square station is being constructed within a tied-

back slurry wall support system in a congested Somerville area." Read "Dirty Work" in the August, 1983 issue of *Technology Illustrated* for a description of geotechnical engineering and what geotechnical engineers do. Haley and Aldrich and Charles Ladd, civil engineering department, M.I.T., are featured in the article. Harl and Lois took a three-week September trip to China as part of a technical exchange arranged by the Association of Soil and Foundation Engineers.

Some of the Harvard University buildings have been surrounded by scaffolding this summer. To anyone who may have had an undergraduate fantasy that old Harvard would crumble away some day: they're not letting it happen. That may be my last attempt at humor at Harvard's expense. Last June, **Ginny Grammer**'s son Ren (my son, that is) was married to Karen Kronauer in the historic Apthorp House at Harvard, now the residence of the Housemaster of Adams House, which was built around it. Karen's parents were the housemasters of Adams House and her father is a professor at Harvard. To balance the picture, my other son, Charles, is a graduate student at Yale. Margaret is working on a degree in journalism at Lesley College, and Beth, a principal partner of Serif & Sons, (typesetting, camera, design) is attending professional seminars. Tomorrow I begin my second year as a professor in the computer science department at Wentworth Institute. But enough about me. Let's hear from YOU.—**Virginia Grammer**, Secretary, 62 Sullivan St., Charlestown, MA 02129

48

Our 35th Reunion in June was attended by about 70 classmates and their spouses. The spacious exhibit rooms at the Boston Museum of Fine Arts provided the opportunity to say hello to one another, and the structural design of the West Wing roof was artistically of interest and provided the engineers among us with a chance to evaluate a complex design. The following classmates have attended most of our seven reunions: **Bob Bliss, Ken Brock, Dan Fink, Dave Freedman, Dave Cist, Harry Jones, Lou Kreek, Manny Kramer, Sonny Monosson, Bill Maley, Ed Newdale, Don Noble, Harry Ottobrini, Bob Peterson, Norm Shillman, John Walch,** and yours truly. **Bill Katz** missed his first reunion this year, and **Rosemary Durnan** (now Mrs. Luciano Scala) attended her first reunion. **George Clifford,** our class president, has already recruited Rosemary to help us invite other women class members to the 40th Reunion.

Some classmates who traveled long distances to attend our reunion were: Barbara and **Ed Cummings, Denny McNear, Al Fioravanti** and his wife and nine children and children-in-law, Joan and **Curt Green,** and Charlotte and **Bob Hanpeter,** and Gloria and **Norm Kreisman,** Norma and **Bruce Morrell,** Margaret and **Cliff Moss,** Imogene and **Jack Page,** Juanita and **Arnold Singer,** Carolyn and **Dick Snow,** and Barbara and **Bill Weisz**.

After Tech nite at the Pops, Rose and **Leon LaFreniere** hosted coffee and dessert at the M.I.T. Boat House. In the morning, breakfast at the M.I.T. Museum provided everyone an opportunity to see Gyorgy Kepes' painting "Open Horizon" (see *Technology Review,* October 1983, p. B15).

By bus (with drinks) and by car (without same), we moved from the campus to Chatham Bars Inn. **Harry Ottobrini** put together a great display of photos and stories about M.I.T. and our class in 1948. After dinner **Milton Slade** and **Graham Sterling** arranged a delightful singing group and a comedian for the evening's entertainment. In the morining **Herb Kurinsky** arranged a very popular tennis tournament, golf, swimming, and sailing. That evening after dinner we elected officers of our class for the next five years: president, **Geroge Clifford**; treasurer, **Miltion Slade**; secretary, **Marty Billett**; assistant secretaries, **Don Noble** and **Sonny Monosson**; estate secretary, **Ken Brock**; class agent, **Warren King**; and vice-presidents, **Jack Page,** Dallas; **Bill Weisz,** Chicago; **Bob Hanpeter,** St. Louis; **F.W. Furland,** Los Angeles; **Bill Hosley,** Rochester; **Harry Jones,** New Jersey; **Bob Sandman,** Newton; **Graham Sterling,** Norfolk, Mass.; and **Lou Kreek,** Baltimore.

Other activities included a clambake, watching movies that **Dan Fink** took of the 30th Reunion, a cocktail party in the new Beach House, a brisk walk on the dunes of Cape Cod, and dancing after the Saturday night banquet. Our class thanks the members of the 35th Reunion Committee for their efforts to plan and implement a fun weekend. **Don Noble,** chairman of the reunion, did a fine job of orchestrating the efforts of many volunteers, each of whom had their own idea of how to run a reunion. Don's wife, Nancy, as usual was a valuable honorary member of our reunion committee. At the class officer's meeting, we voted to give honorary membership in the Class of 1948 to all spouses.

Milton Slade spearheaded the entire program at Chatham Bars Inn. **Mal Reed** edited and put together a fine yearbook of classmates' autobiographies. **Sonny Monosson** did his ususal comprehensive job with publicity and the yearbook. **Bob Sandman** arranged our Museum visit. **Graham Sterling** as class president and Reunion Souvenir Committee chairman contributed extensively. **Jim Manson** recorded every move with camera. **George Clifford** collected the money and paid the bills. This is only a partial list of classmates who helped make the reunion a success.

In addition, **Joe Martori,** associate secretary of the Alumni Association, with his staff took care of many of the details, big and small, needed to house, feed and move over 120 people. After our 25th reunion, we voted to make Joe an honorary member of our class in recognition of his effectiveness.

I called **John Weil** in Michigan and **Jules Levin** in New Mexico just before the reunion. John is chief technical officer of Bendix. He is busy unscrambling and combining related parts of Bendex with Allied after their recent merger. John and his wife, Joan, have two grown daughters. One daughter is a biochemist at Baxter Travenol in Boston. In response to my question about John's contact with classmates he mentioned meeting **Dan Fink** at professional meetings. He has seen **Ken Brock,** and remembered being in student government with **Dave Cist**. John was a member-at-large. John and Jules both send regards to **Ed Newdale**.

Jules Levin is with the Los Alamos National Lab and works in the field of voice and data communications. His son obtained a Ph.D. from Davis and is teaching botany at Ripon. His daughter is in the Graduate School of Public Administration at San Diego State. When Jules was at a national computer conference, he met **Clark Dubois** who had roomed with Jules in our freshman year. Jules remembered playing pinochle and smoking Chesterfield cigarettes with **John Weil** and **Bill Zimmerman** on Saturday nights at Tech.

The mail bag contains enough news for another two columns—thanks for your support.—**Marty Billett,** Secretary, 16 Greenwood Ave., Barrington, RI 02806

49 35th Reunion

Barton Brown has been appointed General Motors' Vice-President, Overseas Group, and will become a member of General Motors Administrative Committee. . . . **Marvin Asnes** is retiring as President and Chief Executive Officer of Becton Dickenson and Co. of Paramus, N.J. . . . **Davis Keniston** continues to work for the improvement of Vermont having just been appointed to the Board of Directors of Vermont Rebuild.

I write these notes in 100° temperature during the hottest summer in many years in St. Louis—for the wintry Nov./Dec. issue of our magazine—and I am urging you to prepare for our 35th Reunion in Bermuda in June. I wish, right now, I were in Bermuda! See you there!—**Paul E. Weamer,** Secretary, 331 Ridge Meadow Dr., Chesterfield, MO 63017

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David I. Caplan has been appointed senior vice-president, technical operations, of Fortune Systems Corp. in Belmont, Calif. . . . **John C. Richardson** writes that he is still with Linde Co. as manager of quality assurance.. . . **Richard S. Bachtell** is chief physicist and manager of the Clinical Radiology Testing Laboratory of Miami Valley Hospital in Dayton, Ohio.—**Gregor J. Gentleman,** Secretary, 818 S.W. 9th St., Des Moines, IA 50309

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Over the summer you should have received letters about our 30th class reunion and other information from **Fred Brecher** and **Joe Cahn**. We are going to try extra hard to keep you up to date on what's up with the Class of '53. You can help by dropping a line about yourself, your family, job, ex-job now that you've retired, grandchildren, social life, professional affiliations, or even what or whom you'd like to hear about in this column.

Several of us are still connected to academia. **Ed Leonard,** who is a professor of chemical engineering at Columbia University, was just elected a Fellow in the AIChE for his research in biomedical engineering, applying membrane processes to artificial kidney development. . . . **William Bertozzi** writes that he's a professor in the M.I.T. Physics Department. . . . A news clipping informs us that **Alan J. Lazarus** is performing research on solar winds in M.I.T.'s Department of Physics and was recently named acting academic officer for the department.

A new company, Infranor, Inc. has been formed to manufacture and market servo systems used for robotics and other purposes, and **Willard B. (Bill) Spring** has been elected its president. . . . We hear that **Theodore H. Bodner** has been appointed director of orthopedics at Hackensack Medical Center in New Jersey. . . . **Al Gallagher** is now a process engineer for the Stearns-Roger Engineering Division of Air Products Corp. . . . **Dave Klepper** writes that he's still busy with acoustical consulting projects at Klepper Marshall King Associates such as the construction of a Tanglewood-like facility for the Rochester Philharmonic at the Community College of the Finger Lakes in Canadagua County, N.Y.

Although most of our classmates live and work in the United States, some do not. **Richard A. Lockhart,** for example, says that he's currently working in Saudi Arabia as a civic planning advisor to the kingdom's Air Defense Command.. . . **John P. Medgyesy** has provided us with some family news. He and Carolyn saw their daughter Susan married recently, and they became the instant grandparents of three young boys, the sons of their new son-in-law, Joe Walker. John and Carolyn are part of the 84 percent of our classmates who are still married to their original spouses. Let's hear from more of you about your family events. If not, I'll have to tell you about Berna's and my forthcoming grandchild, who is expected around publication time, thanks to our son David and his wife Maureen.—**Wolf (Bill) Haberman,** Secretary, 41 Crestwood Dr., Framingham, MA 01701; **Joseph Cahn,** Assistant Secretary, 289 Bronwood Ave., Los Angeles, CA 90049

54 30th Reunion

In contrast to those of us who have made several changes in our professional careers, **Sam Armour** has found a home at the General Electric Co. Sam has been designing gas turbines and nuclear reactors for G.E. for over 20 years. Since leaving Tech, Sam has earned an M.S. in civil engineering and professional licenses in mechanical, nuclear, and quality engineering.

Our erstwhile Class President, **Larry Holmes,** found his home at Yale University. He is head of the section of the history of medicine in their medical school. In addition, he is Master of Jonathan Edwards College there. In his "spare" time this

Anne Cunningham (left) and James S. Draper, '62, a trustee of the Cunningham Fund, congratulate Linda Zelinka, the first James E. Cunningham scholarship recipient. James Cunningham, '57, had an "abiding sense of what an M.I.T. education had meant to him," said Draper at the awards presentation during the National Alumni Conference in September. It is the first endowed scholarship fund at M.I.T. expressly restricted to undergraduate women in engineering. An active alumnus, Cunningham was a member of the Educational Council, the Alumni Council, and served his class as treasurer, president, and 15th reunion chairman.

summer Larry also managed to write a book.

Dean Jacoby reports that he is leaving the Polaroid Corp. after ten years to launch a new company providing specialized computer software for multinational businesses. Good luck Dean!

Our 30th Reunion plans are on course. Pops, champagne reception with Priscilla and **Paul Gray,** dinner at the swank Hotel Meridien, New England clambake, etc. It promises to be a great time, so plan to attend (June 7-10). Please return your reunion response cards and send in your class dues. Thanks.—**William Combs,** 120 West Newton St., Boston, MA 02118; **John Kiley,** 7 Kensington Rd., Woburn, MA 01801; **Louis Mahoney,** 52 Symor Dr., Convent Station, NJ 07961; **Dominick A. Sama,** 28 Chestnut Hill Rd., Groton, MA 01450

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Roger S. Borovoy is now vice-president of Sevin Rosen Management Co. and will head their West Coast operations. Rosen, Sevin and Borovoy will offer their first round of financing to high-tech start-ups. They will serve on the boards of these new ventures and assist in the management of each budding firm. "These start-ups will be selected according to three criteria," says Borovoy, "1) People, 2) People, 3) People." While they will consider everything from robotics to genetics, special consideration will be given to entrepreneurs whose applications call for the use of 32-bit microprocessors, like the National, the Motorola, and the Intel 386 and 432 microprocessors standardizing around 8086 architecture. Asked if the group is looking for no-risk deals, Borovoy responded with an emphatic no. He says there's always a certain amount of risk involved—the risk is minimized when the people, the product and an experienced management team find each other.

The American Nuclear Society has selected three men from Ebasco Services to receive the Society's 1983 Special Award for a team effort. One of those selected is **Benjamin E. Tenzer III,** who with Leonard Reichle and Bertrand Mazo was chosen for foresight and pioneering effort that played an important role in guiding the establishment of sound quality-assurance practice in the nuclear industry. Awards were presented at The Westin Hotel in Detroit during the Society's 29th annual meeting.

Your western co-secretary spent a very interesting month in Venezuela. Caracas, the capital, is all excited with the coming elections in December: there are slogans painted on many walls, and political advertisements abound. The city is beautiful, full of construction activity, and boasts a modern subway and a fantastic theatre, the Teatro Teresa Carreno, which has excellent acoustics. And Caracas has the perfect weather which other places claim. But with 3 million inhabitants in a narrow valley, the traffic is a problem, which is one reason the subway has been such an improvement. One of the highlights of my trip was a dinner at the Restaurant Da Emore which I think is a must for any visitor to Caracas—fabulous food and service. **Isaac Foinquinos,** who started out with our class, organized a group of alumni and families to dine at the Da Emore. Isaac is still the energetic, enthusiastic young man we remember, truly the life of the party. His warmth and hospitality will be long remembered and appreciated. Gemma, his wife, is a lovely lady, and they have three children, one of whom I had the pleasure to meet—Carlos, 15 years old, a great golf player who had just won a 3rd place in a tournament. At our dinner party also was **Francisco Villanueva,** now a banker, with four children, the oldest a graduate of Babson. There was a lot of teasing about how Francisco looks like a banker. **Luis Franceschi** and his wife Dinah (an old friend of mine from high school days) were a pleasure to see, looking unchanged by time. Luis is teaching at the University in addition to owning a consulting firm. **Nelo Sekler,** president of Oxy Metal Industrias, was also there with his wife Eva, a physician who I found out works with my brother-in-law Juan Godayol in the Centro Medico of Caracas. Nelo asked about news from some of our classmates, assuming that being a co-secretary I had a great deal of information. **Manuel Isava,** a hydraulics consultant, was also present with his lovely wife. We reminisced a bit and also congratulated ourselves on how well we looked! In addition to these classmates, we were joined by Alfredo Peralta, '54, an old neighbor of mine, who has been working with the Corporacion de Guayan. **Roberto Pardo** was not able to join us because he was sick with mononucleosis. He is working with computer simulations and is president of his own firm of consulting engineers. Those of you who attended the 25th Reunion may remember the full size slide we saw of Roberto on graduation day. **Hugo Fonseca,** very involved in politics, and I saw a newspaper article analyzing the economic situation in Venezuela. **Bernardo Blaschitz** was not able to be with us either, but I enjoyed a phone call with him. His wife Milagros graduated with a child psychology-related degree. This led us to comment on our upbringing, which was before the era of psychology—and look how well *we* turned out. The M.I.T. Club of Caracas is an active group which meets every month. President Gray recently visited Venezuela and was much enjoyed and feted by the M.I.T. Club and representatives of the Venezuelan government. He visited Angel Falls and the hydroelectric plant at Guri, among other things. In addition to inquiries about fellow alumni, a lot of our conversation centered around the economic situation of Venezuela. The Bolivar is going through some difficult times and has been devalued. The situation is being very closely watched and a lot of interest in the coming elections is based on speculation of what might be done to stabilize the currency and the economic situation. Nothing like leaving home to make you gain some perspective. Our economic problems in the U.S. didn't seem quite as bad after I came back.—Co-secretaries: **Caroline D. Chihoski,** 2116 W. Davies Ave., Littleton, CO 80120, (303) 794-5818; **Robert Kaiser,** 12 Glengarry, Winchester, MA 01890

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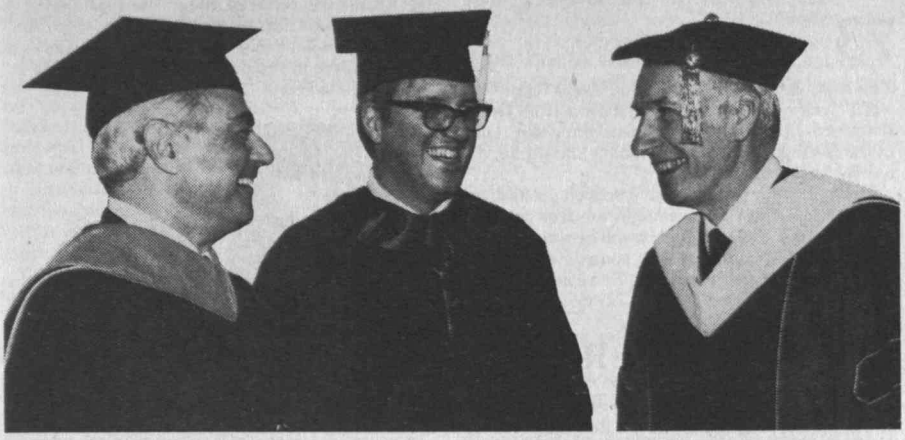
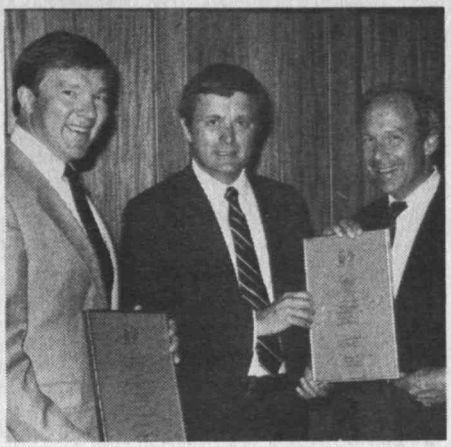
Our 25th Class Reunion was a smashing success. With sensational weather and a schedule of activi-



"It is time that the members of the engineering profession get out of the laboratory and begin to participate in the management of our society," Talbot S. Huff, '62, (above center) vice-president and general manager of the Melpar Division of E-Systems, told graduates of George Washington University last June. (He is flanked by Harold Liebowitz (left), dean of the School of Engineering, and Lloyd H. Elliott, president of George Washington University.)

Engineers have tended to leave significant decisions in industry, government, and education to individuals having little or no knowledge of technology and its role in the world, he said. He encouraged engineers to lead, using their knowledge to anticipate the future.



Harbo Jensen (left), Ph.D. '74, outgoing Club of N. California president, presents the Lobdell Award to Roger Borovoy (right) '56, who begins a term this year as the Alumni Association director of District 9. Bill Murray (center), '67, is honored with the Alumni Association board of directors' resolution recognizing the club's support of AOC '82.

ties that taxed all our energies, the reunion was a delight for all 135 classmates, plus their wives, husbands, friends and children who brought the total attendance to nearly 300 people. Planning for this five day "spectacular," which took place both in Boston and on Martha's Vineyard, required super-human efforts by the Reunion Committee. Our thanks from the class to **Martin O'Donnell**, Reunion Chairman for his truly outstanding efforts. Special thanks also to **Roy Scarpato** and **Howard Salwen**, who developed the class questionnaire and profile; **Bob Ricci** for the souvenirs—a giant-size M.I.T. class ring; **Steve Hadjiyannis** for his efforts as reunion treasurer; **Pete Recupero** for handling transportation arrangements; **Glenn Strehle** for managing the athletic events (back to where he started!); **Frank Tahmoush** for the Vineyard logistics; and **Dick Rosenthal** for initiating early plans. Assisting in these activities were **Liz Drake**, **Dan Holland** and **Bill Jordan**.

And, despite the combined effects of recession and college-age children, our class came through with a total gift of $702,407, which includes a designated gift of $313,123 for the Class of 1958 Assistant Professorship. Our class is deeply indebted to **Joseph Gal**, who served as Reunion Gift Chairman in the most difficult of times. Little did Joe suspect, when I recruited him to serve in this capacity, that it would be such a time-consuming job. But, thanks to Joe's tireless, almost full-time efforts devoted to this task, our class gift level was exceeded in the past ten years by only two other 25th Reunion classes. Thank you, Joe, for a job well done. We also wish you continued success with your venture capital firm, Gal Capital Management Co. in Beverly Farms, Mass.

Some of the highlights of the class questionnaire, presented by Roy Scarpato and Howard Salwen in a stand-up comedy routine reminiscent of Rowan and Martin, included the fact that the average weight gain, down to two decimal places no less, was 19.56 pounds. Nearly two-thirds of us have advanced degrees, but only 25 percent are working directly in science and engineering, while another 17 percent are in engineering management. Confirming observations made in this column earlier, we are an entrepreneurial group with nearly one-third of the class involved in their own businesses. We have children, lots of them, something close to an average of 2.5 per family. We own houses, live in the suburbs, drive 2.2 cars, don't go to church very regularly, and vote middle of the road to slightly conservative on most issues. Most of us are very happy with our work, but are less optimistic about the world outlook over the next 25 years. As a result, the 50 percent of the classmates who still have all their hair can be counted on to have less by the next reunion.

In the next issue we'll have more of the news gleaned at the reunion about the activities of our peripatetic class.—**Michael E. Brose**, Secretary, 59 Rutland Sq., Boston, MA 02118

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It's really tough writing a November-December column during a late-August heat wave.

David G. Johnson, is the number-two officer of Automation Machinery and Development Corp., Stamford, Conn., which does engineering consultation and constructs equipment. (The "number-one" is M.I.T. '48.) Dave has lived more than 20 places in three countries (most recently, Nashville, Tenn.), but now lives "in what must be best—Guilford, Conn.," 55 miles from work." Dave's son was 21 in July and is at Auburn University in Alabama; his 17-year-old daughter has been accepted at Vassar and Vanderbilt, and at last word was awaiting other decisions. There are also another son (14) and another daughter (7). Dave and his wife, Lyla, have been married 22 years. She is active in local community activities while taking a sabbatical from nursing. . . . **Victor Scheinman** is vice-president for advanced systems and founder of Automatix, Inc. The corporation went public last March, and specializes in "robotic systems." Victor and his wife, Bonnie, have a daughter, Tenaya, who is about 4, and were expecting a second child near the end of May. We have a report that **Paul Richman** has been elected chair of Standard Microsystems Corp. of Hauppauge, N.Y. He also remains president and chief executive officer.

Everyone who wrote in this month seemed to be president of a company or full professor at a prestigious university. I figure by now most of those guys have already written, so it's time for us ne'er-do-wells to have a turn. Shy people of the world, unite! To support this, I will award a prize—I'll figure out what later—to the class-member/correspondent who sends in the most mundane report each month. This month I award myself the prize. I am president or vice-president of nothing (although seven years ago I was president of my neighborhood association). I live in a modest row house with my wife, Linda Marsden, a cat named Betsy, and sometimes my 13-year-old son, Gary. Two of my favorite activities are listening to classical music and churning out gibberish like this on my word processor. Merry Christmas, Happy Chanukah, and have a happy (i.e, *sans* Big-Brother) 1984. See you next time.—**Phil Marcus,** Secretary, 2617 Guilford Ave., Baltimore, MD 21218

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Happy Thanksgiving and Merry Christmas. As some of you may know, each issue I receive an envelope from the Alumni Association that contains a deadline notice and the month's accumulation of Alumni Fund envelopes. Those envelopes (or more properly the notes on them) are the raw material for the column. This month (late August) the envelope contained nothing but the deadline notice. So the column is thin.

We just got back from summer vacation at an Appalachian Mountain Club camp in Maine. Anne and I and the kids spent a week living in a tent, rising to a bugle (sometimes a saxophone), eating in a dining hall, and hiking and swimming to our hearts' content. It was great. Now I am back to trying to make DEC's computers more secure, and Anne has returned to administering the Sloan School. I think we wish we were still on Mt. Desert

Island.

Write next year, and the columns will be longer.—**Steve Lipner,** Secretary, 6 Midland Rd., Wellesley, MA 02181

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"Hello Jim - I'm the wife of **Steve Braunstein**. Of course, Steve won't send you any news, so I thought I would. We are the parents of Kathryn, born at our home on April 6, 1983, and Timothy, almost four years old. I'm a lawyer, and Steve is still with I.B.M. (16 years with them, except for the U.S. Navy), and we wish we didn't live in San Jose, though we've been here nearly ten years! Sincerely, Jill Cooper." That's all, folks. No news from any classmates. My thanks to Jill for writing the class notes this month.—**Jim Swanson**, Secretary, 878 Hoffman Terr., Los Altos, CA 94022

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Gordon Tyler, Jr., after moving into the program management at John Hopkins Applied Physics Laboratory, recently became the father of twin boys. . . . **Howard Manasse** lives in Erie, Pa., and is an ophthalmologist. He has passed his board certification and is a fellow of the American Academy of Ophthamology. He is presently married and has two children. . . . **Richard Nagy** is working for Raytheon Co. as a software project engineer in the Hawk Program Management office. He lives in Acton, Mass. . . . **Steve Cohen** has two children and lives in Palo Alto, Calif., and he works at Hewlett-Packard as a sales manager for Electronic Components.

Dan Kidd is alive and well in the Maine Woods. His employment plans are uncertain at this time; however, he does intend to plant corn, potatoes and pumpkins while contemplating the opportunities for high tech industry in Allentown, Pa. . . . **James Korff** is now married and lives in Foster City, by the bay. He is presently designing structures at Helios Industries after four years of architectural practice in San Paulo. . . . **Julia Norton** has been teaching at California State University at Hayward in the Department of Statistics. She took a year off and taught statistics at the University of South Pacific in Suva Fiji while her husband was a Fulbright Scholar in the Fiji Islands. She has had success in presenting papers at various International Time Series Conferences, and loves teaching as an associate professor.

Jeffrey Ellison is married, has three sons and lives in Easton. He has recently been named production manager of manufacturing at Reed and Barton Silversmiths. . . . **Franklin L. Deremer** is an adjunct professor of computer and information sciences at the University of California, Santa Cruz, and president of Metaware Inc. He is specializing in LR(k) techniques of compiler writing and is actively involved in an institute of computer science at the university. . . . **Michael Genesereth** is an associate professor of computer science at Stanford University with his primary interest in Construction of Programs at perform and expert level in complex fields like mathematics and education.—**Robert O. Vegeler,** Secretary, Dumas, Backs, Salin, and Vegeler, 2120 Ft. Wayne Natl. Bank Bldg., Ft. Wayne, IN 46802

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The amazing **Grethe Holby** writes, "Just finished up as a choreographer and assistant director of the Leonard Bernstein premiere, "A Quiet Place," at the Houston Grand Opera—then on to the Kennedy Center and La Scala (Milan). Made directing debut last summer at Wolftrap and debuted at Kennedy Center choreographing a new opera by Menotti this April. Getting married on July 23 in NYC to Arthur Elgart, a fashion photographer for *Vogue* magazine." Congratulations; had I known that a '71er was working on the Bernstein opera in Houston I would have gone.—**Hal Moorman,** Secretary, P.O. Box 1808, Brenham, TX 77833

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One lousy letter this month! Tsk, Tsk. Well, it wasn't lousy, it was polite, and it came from **Dean Bohjanen**. He is still involved with punching holes in the Michigan basin. Occasionally, quoth he, a few hydrocarbons leak out.

That's it! Ruth and Bob have broken ground on "Chapel Hill," our new estate in the area of our present home. By December, it will be ready, knock on wood. Let's baptize it with some letters, shall we?—**Robert M.O. Sutton, Sr.**, Secretary, 24 Princess Anne Ct., Warrenton, VA 22186

74 10th Reunion

Hello class. The hardest part of being a Class Secretary is announcing the death of a classmate. **Nancy J. Bryg** passed away in October of 1982. I didn't know Nancy well, only to say "hello" on the way to classes. Still, it makes me think . . . and remember . . . and then turn off the typewriter. I think that the same feeling touches all of us.

Next to the numerals at the beginning of this column is a reminder: our 10th Reunion is getting very close. Those of you that are still thinking of getting involved with the Reunion Committee should probably do it now. Otherwise you'll be on the 15th Reunion Committee. For those of you who feel that you are too far away to participate in the Reunion, there may be an alternative! Please get in touch with either Lionel or myself at the addresses below. There may be some way of arranging some kind of "alternative reunion" for those of you that are beyond lunar orbit (or help, whichever is more immediate).

Many of you may not be aware of the Class of 1974 Health Fitness Center or the "weight room" as it was once known. This project is our Class Gift. It needs a new name. Perhaps something like "Club 74" would be more appropriate. This piece of class business is open to debate.

Mark D. Webster finished his orthopedic surgery residence at Northwestern University Medical Center in Chicago last July. He is currently engaged in private practice in Newport News, Va. . . . **Lawrence Russell** is still engaged to Sharon Harris the last time I received a note from him. So Larry, when's the wedding date? I can't keep submitting engagement notices indefinitely.

John Hixson and his wife Janet are still working on their 1893 house. John is the housing director for a non-profit agency in Somerville that was responsible for the construction of thirteen new houses in 1982 with more to come by the end of this year. . . . **Mark D. Feldman** is an assistant professor in the economics department at the University of California at Santa Barbara. He and his wife have a two-year-old son. . . . Mrs. **Abbie Sue Carlstein Gregg** (Abbie, I haven't seen you or Randy in years!) is now Module Operations Manager for a new integrated circuits manufacturing facility at G.T.E. Microcircuits in Tempe, Ariz. Her husband Randy (Class of '71) is working on automated assembly equipment engineering at Motorola. Abbie says that they love Arizona.

Hugh Gordon Deen, Jr. will complete his neurosurgery residency at the Mayo Clinic by June, 1984. . . . **Eugene E. Bouchard, Jr.** writes that he is with Lockheed Co. (in California) after receiving his Ph.D. in mechanical engineering from Stanford Univ. in 1982. . . . **Thaddeus (Ted) P. Kochanski** is still working on soft x-ray imaging of plasma instabilities at the University of Texas at Austin. Ted: I will try to track down your subscription to the *Review*. I hope that you remembered to send at least ten dollars ($10.00) to your favorite Alumni Fund category every year to continue receiving this incredible sort of monthly down-to-earth and out-of-this-world intellectual workingman's magazine. This rule even applies to me.

Last April, in Bombay, India, **Rajendra Shah** was married to Shefali Balsari. From all reports, the wedding was quite an extravaganza! . . . **Saequa Dil Vrtilek** has received one of the 1983-1984 ZONTA Amelia Earhart Fellowship Awards. The $5000 grant will be used to further her studies as a Ph.D. student in the department of astronomy at Columbia University.

Saequa Vrtilek

Aviva Weisel Eichler writes that she and her husband have a third son, Ari, who was born last June at their home. For the past year, she has been teaching high school math. The year before, her family spent one half of the year in Israel and the other half in Santa Barbara. In the coming year, the family will again reside in Israel. . . . **Richard A. Hartman** writes that he is engaged in private practice in Clayton, Missouri. He has extended an invitation to any old friends coming through St. Louis to drop in or call him. Sounds like a four-star establishment. . . . **James R. Andrew** writes that he was appointed as the director of research and development at North American Biologicals, Inc. (N.A.B.I.) last December, 1982. He is also the president of State Street, Ltd. Boston which is a private investment consulting firm. During the past year, he has been the captain of *Obsession-'46*, an ocean racing sloop in the 1983 Southern Ocean Racing Conference.

Meanwhile back in Rochester, Minn., **Baird Swanson** and his wife/childhood sweetheart of 10 plus years live the peaceful life with their three boys. However, in the background, lurks the shadow of I.B.M. where Baird spends much of his time as a senior associate programmer unraveling the dark and mysterious (even to the original designers) secrets of MVS and JCL. Keep up the good fight!

John L. Daiss and his wife, Meg (nothing to do with memory), are renovating an " . . . old and abused home . . ." where they are hoping to have lots of visitors. The address is 30 Lakeview Park, Rochester, NY 14613. No reservations necessary. You can park your Airstream campers on the front lawn. Also a four-star rating. . . . **Gregory Turner** became an associate at CRS, Inc. (the Houston-based international architecture, planning, interiors and engineering firm) sometime late last summer. Greg, are you still in Houston? . . . Last May, I ran into **Paul Schindler** (if you can believe that) at the National Computer Conference in Anaheim, Calif. He is back as west coast editor of *Information Systems News* after a six month stint as a consultant. Paul, you really are looking quite prosperous. See you in Las Vegas this coming May or at least at the 10th Reunion in June, right?

Joe Sulmar's remarks concerning his activities have meaning for many of our classmates who are making the same transition. He writes: "I recently quit my job at Teradyne to establish Sulmar Systems, a data and video communications consulting business. The change from engineer to entrepreneur is a big one, but it has been very stimulating and fulfilling." In a similar fashion, I have been consulting to Digital Equipment Corp. for some time now (exclusively for almost a year!) after becoming quite bored with the traditional route. It's hard work but as Joe knows, it works.

So get set for the 10th Reunion. Please keep in touch and drive very, very carefully all the time (not only during the holidays!).—Co-secretaries: **Jim Gokhale**, 12 Pond La., Arlington, MA 02174; **Lionel Goulet**, 34 Tremlett Sq., Dorchester, MA 02124

75

A backlog of class news has developed, which I will try to whittle down over the next few months.

Lewis Weinstein is vice-president for strategic planning and acquisitions at Far West Financial, a savings and loan holding company. . . . **Michael Wilens** is living in Ann Arbor, has received a Ph.D. from the University of Michigan, and has formed a computer company which has grown to 25 people. . . . **Leonard Weiss** is a fellow in the Department of Nutrition at the Memorial Sloan-Kettering Cancer Center in New York; he is board certified in Internal Medicine.

Peter Chu received an M.S.E.E. degree from the University of Illinois in 1976; he worked for two years at Hewlett-Packard in Palo Alto, then got a Ph.D. in E.E. at Berkeley in 1981. Currently he is doing research on speech processing and modems at Codex Corp. in Mansfield, Mass. . . . **David Kelly** is still working at Walt Disney productions: "Sweated some long hours helping get EPCOT center open in Orlando. Now involved in some exciting projects for the next phase of EPCOT—we never stop!". . . **Bruce Miller** was married to Oleta Davis (William and Mary, '75) on April 9 in Iowa City, Iowa.

Andrea Reyman Hiner is working in New Orleans for Shell Oil Co. "Very exciting. I love the job, a combination of offshore field work and office work." Last May, after getting married, she traveled to Africa on a safari. . . '. **Kenneth Strzepek** is a free-lance consultant working out of Vienna, Austria, on industrial and agricultural water management. "Enjoying the strudel and occasional skiing."

Sherwood Pidcock says, "I bought an American Sun Systems solar water heater for my home in Boston. This is the last year for Massachusetts solar tax credits of 21 percent in addition to the federal credit of 40 percent." Did you know that? . . . **Alwin Okuna** received the M.S. degree from the University of Southern California and now works for Hewlett-Packard in San Francisco. . . . **Anita Horton** is still working for Crocker Bank, also in San Francisco. . . . **Loren Dessonville** is practicing law at Kutak Rock and Huie in Omaha, specializing in energy-related project financing.

Robert Rosenschein worked for three years at American Management Systems in Arlington, Va.; then he formed his own consulting company specializing in minicomputer and microcomputer software, especially Unix. He moved to Israel last summer with his wife, Diane, and two sons, Avi (5) and Dov (1).. . . **Steve Slesinger** and his wife, Shelly, have a baby girl, Sarah Michelle, who was born on March 8. . . . **Mitchell Tyson** received his S.B. in physics in '75, S.M. in Nuclear Engineering and S.M. in Political Science both in '78, and has satisfied all requirements for an interdisciplinary Ph.D. in Energy, Technology and Policy except the dissertation. For the last five years he has been senior legislative assistant to Senator Paul Tsongas (Democrat, Mass.). He is responsible for high technology, energy, defense, communications, science policy and industrial policy. . . . **David Dinhofer** writes "I was unhappy at the program in internal medicine at Maimonides Medical Center in Brooklyn, N.Y., so I left and accepted a position at Huron Road Hospital in Cleveland as chief resident in internal medicine. I will complete my training in January, 1984, and plan to do a cardiology fellowship after that." . . . According to **Jim Demers,** "After seven years of graduate and post-doctoral research, I am finally out in the real world making real money (and paying real taxes). I am working for Ortho Pharmaceutical Corp. (in beautiful Raritan, N.J.) as a medicinal chemist, concocting the wonder drugs of tomorrow. (A cure for the hangover is *still* 50 years away though). Living in Manhattan still—I am not ready for the suburbs yet.". . . **Edward Capparelli** and his wife Gillian moved to Hondurus in June to do medical work among the Miskito Indians. Edward is an M.D. and Gillian a nurse; their work is sponsored by the Reformed Church in America missionary program.

On or about June 4th, 1983 a small group of '75 alumni got together in Concord, Mass., for the wedding of **Richard J. McCarthy** and Judith Thompson. On hand were **David K. Gifford,** who is now an assistant professor of computer science at M.I.T., **Charles Fendrock** of Symbolics, Inc., and **Alex Castaldo,** occupation unknown. A good time was had by all; best wishes to the bride and groom. . . . Congratulations to **David Wargo,** who is now a partner of State Street Research and Management, Boston, Mass., where he has worked for the past five years.—**Alex Castaldo,** Secretary, 929 Massachusetts Ave., Cambridge, MA 02139

76

Greetings from the Far East. Unfortunately, these notes were due before my mail had a chance to catch up with me. However, I have had phone calls with **Dan Dershowitz** and **Ricky Farber**. Dan and wife Debbi Gross, '77, are happily enjoying life in Westchester County, Dobbs Ferry to be exact. Dan spoke with **Gary Buchwald**, who is apparently having a very successful time at Analog Devices and is the proud parent of two children now. He and Michelle, '78, are still living in Sharon, Mass., a lovely town not too far from where your secretary grew up. . . . Ricky is fine as well, and is enjoying his work at Coopers & Lybrand in New York.

As for your secretary, he has indeed taken up residence in Hong Kong. This city is truly the Pearl of the Orient. Its beauty is so great as to be breaktaking, especially when seen at night from the top of Victoria Peak. Being an expatriate is already becoming an interesting experience. I recommend it for those who may have an opportunity to do so. I am starting to learn a little Chinese. Fortunately, everyone I deal with on a business basis speaks fluent English. I have begun apartment, or as they say here, flat, hunting, but have not yet chosen a new home. When I do, I'll let you know. Real estate prices have fallen, but the rents are still steep in comparison even to New York. However, food of all types is relatively cheap. Hong Kong is a very cosmopolitan city, and it is just as easy to eat French cuisine as a variety of Chinese styles.

Insofar as trading is concerned, Hong Kong has a nice benefit. I work nights and sleep in the morning, with my secretary giving me my wake-up call. I am 12 hours ahead of New York. And as for the markets, soybeans and Treasury Bonds continue to move big, and, of course, the foreign exchange markets continue their rather frenzied pace. Also, we have had some big plays in stock indices, gold, and heating oil. Trading is never dull, regardless of the locale.—**Arthur J. Carp,** Secretary, Sun Hung Kai—Merrill Lynch Commodities, Ltd., 3rd Floor, Admiralty Centre, Hong Kong, 5-290289 or 5-272178

77

Well, last month I had too much news to fit in. This month there is only a little news. Please do write; tell us what you're doing, where you've traveled, hobbies you've discovered, etc. While some have accused me of too much creative license on occasion, there is no way I can fabricate a column. So, get out your pens and write! Also, please write your names legibly. Sometimes I have to guess the identity of the author, and don't always succeed. Perhaps someone out there who regularly sees more alumni than I do would like to write an occasional column or section—I'd be delighted to share the space.

Stephan J. Mallenbaum is getting married this summer to Suzanne Garber, Wellesley, '82. After three years of practicing corporate and securities with a Boston law firm, Stephan has moved to New York City where he is now specializing in representing high-tech ventures. . . . **L.K. Woo** is working on advanced computer research with Raytheon Electro-Optics Labs for N.A.S.A. meteorological Doppler Lidar system, and states, "Have strong desire to buy commercial ticket to self-sustaining colony on Ceres."

That's all the news for this issue. I hope to share more with you next month.—**Barbara Wilson Crane**, Secretary, 6431 Galway Dr., Colorado Springs, CO 80907

78

I have come to the conclusion that almost nobody in the class traveled this summer—how else can you explain the miniscule number of boring postcards I received? Come on folks—get on the stick and send me your news on a tacky postcard.

One of the postcards that I received was decidedly not boring. **Mike Geselowitz** sent me a gorgeous postcard from Lyjbligana, Yugoslavia, where he spent part of the summer on an archeological dig. The rest of the summer was spent traveling in various parts of Europe, unearthing pottery shards and being a tourist. . . . **Julie Keller**'s postcard was a really dull shot of the Twin Cities Airport. Julie has left Minneapolis and is now enjoying her psychiatry residency in Burlington, Vt. . . . the only other postcard I got didn't have a picture—but no picture was necessary to show the smiles of **Don Meller** and his wife Ann announcing the birth of their second daughter, Pamela Ann, born July 2, 1983. . . . More smiles from **Christine Vogdes** and **Greg Alexander,** who recently married. Greg is finishing his chemical engineering Ph.D. at Berkeley; Christine is working for Raychem Corp. in Menlo Park. . . . Another marriage: **Robert Schloss** married Rene Rosenson of Brooklyn, N.Y. this past May. They'll soon be a two Ph.D. family—Rene has her doctorate in immunology from Harvard, and Bob expects his electrical engineering next year.

Unsubstantiated rumor department: News has reached me that **Yvonne Tsai** has taken her M.D. and gone home. Yvonne finished her internship at Mt. Auburn Hospital and is now doing an ophthamology residence in New York City. . . . And speaking of unsubstantiated rumors, **Regina Wiedenski** and her husband, Brian Backner, '77, did *not* come to the reunion as part of their honeymoon. Regina came to the reunion *after* their honeymoon, while Brian was painting their new apartment in Brookline, Mass. . . . Theresa and **Doug Danley** have returned from Botswana, where they spent four years as Peace Corps volunteers. They're living in Arlington, Mass., while Doug goes back to the 'Tute.

"Gloom and doom have the oil patch by the jugular vein," writes **Rich Fagin**. "Most of the independent producers have laid off professional staff. If we don't get a good Middle East war soon, we *all* will be making hamburgers at Whataburger! Not much to do at the office these days since our developmental drilling program has all but stopped. Oh well, as long as the paychecks keep coming in. At least I can go to the beach when it gets too quiet to work." . . . **Joseph Carretto** writes that the air force has promoted him to captain and given him a M.S.E.E. degree (from the Air Force Institute of Technology). Joe is now working as a space shuttle flight controller at the Johnson Space Center in Houston. . . . More degrees: **Mary McNally** got her M.B.A. from Harvard in 1982 and is now working as a sales engineer for Teradyne, Inc. . . . **Gary Hattery** got his M.B.A. from Ohio University in 1982—the same year as the birth of his son, Russell. Gary recently published a paper in ACS Seminar 212 and presented a seminar on Radiation Processing of Polymers.

Lorne Greenfield writes that he has recently begun working for Power Construction in Chicago. His latest project is building the Westin Hotel O'Hare, a luxury hotel near the world's busiest airport. . . . Also in Chicago is **Beth Plasse,** who has left Shell to complete her M.B.A. . . . **Peter Costagna** writes from suburban Boston that he is working for Raytheon Data Systems as an assistant engineer in distributed processing systems and network hardware. . . . **Dan Ebrom** had so much fun at our reunion that he decided to spend the summer in Boston. I ran into Dan downtown the day

before he flew off to return to Houston. . . . **Skip Page** spent the summer working in Data General's Westborough office building (made famous in *The Soul of a New Machine*). This fall Skip returns to Sloan to finish his M.M.S. while wife **Debra Abbot Page** supports him by working for a prestigious Cambridge architectural firm.

ANNOUNCEMENT: The officers of the Class of 1978 are happy to announce (drum rolls please) the initiation of a program of activities for classmates and other young alumni. These activities will begin with a series of social events in Boston, and will rapidly expand to other urban areas and to professional and financial activities. If all goes well, we hope to have events from Bar Harbor to Peoria to La Jolla. As usual, we will need assistance from classmates across the country. If you have even the vaguest interest, please contact me at the address below or class president **Jim Bidigare** at (617) 576-2552. It'll be fun and possibly even rewarding.

Your secretary has had a good, though uneventful summer. After a year of marriage, I have finally gotten used to the words "wife" and "husband" and to wearing a wedding ring. The word "anniversary" will take some time though. Send me news, gossip, or rumors—but send me something. I need news. And it wouldn't hurt if it's on a boring postcard.

—**David Browne,** 50 Follen St., No. 104, Cambridge, MA 02138, (617) 491-5313, work 727-1190

79 5th Reunion

Hello, classmates. I almost didn't write this column because I was so disappointed by the trickle of mail, which this month came to a dead halt. But then I decided that the few people who did contact me shouldn't have to suffer because the rest of you are deadbeats. So here goes.

Joel Bluestein dropped me a postcard in June from Peking, halfway through a five-week visit to China. Writes Joel, "After four years in Washington, D.C., as an energy systems engineer for the MITRE Corp., I have retired and am traveling in Asia. I will probably return to Washington (maybe in October) to consider a comeback in engineering." In addition to China, Joel was planning to visit Japan, Thailand, Burma, and Indonesia.

Don Berry is only three months from his Ph.D. in chemistry from Caltech. In January, he plans to start a post-doc at the University of Rochester, although he is not looking forward to giving up the beautiful weather of Pasadena. . . . Cathy and **Dan Jaime** left North Carolina in February after three years, and got to their next home in Lawton, Okla., the hard way—driving 4,000 miles with their four children! On the way, they visited **Mark Schwartz** and his wife Sharon in Goldsboro, N.C. Other visits to friends and relatives were made in Maryland, New Jersey, Pittsburgh (where they visited M.I.T.ers Hal, '76, and Cindy '77, Berman); Tennessee; Houston; McAllen, Texas; Hualahuises, Mexico; and Dallas. Still with the U.S. Army, Dan will be taking an advanced course in Oklahoma that finished in mid-October, then on to more training in El Paso before joining a unit in Germany.

Hope to hear from more of you next time.—**Sharon Lowenheim**, Secretary, 131 E. 83 St., Apt. 2G, New York, NY 10028

81

I offered to give **Chuck Markham** a hand in writing the class notes and the guy actually took me seriously, so here goes. . . . First, Chuck was just best man at **Josh Littlefield**'s and Suzy Grove's (Wellesley, '81) wedding at the Wellesley Chapel. . . . **Stephen Vaughn** writes that he is now in graduate school at the University of California, Irvine, and asks anyone who made the Newport-Ensenada crew run to drop him a line. . . . **John Wenn II** is at Xerox doing CAD work, but may go back to "the little schools—Stanford, M.I.T." for an advanced degree.. . . "San Francisco is a blast," writes **Sunil Sanghvi,** who is now working for Chevron and will be blasting off to Salt Lake City to drill for oil shale come October. . . . **Jay Napolean,** at the Medical College of Virginia, is playing tennis and is in a band called "The Blue Dudes of Slude." When do we see an album? . . . The *U.S.S. Richard Russell*, which is now based in San Francisco, is the current address for sonar officer **Tom Eccles**.

Mike Mainiero is also enjoying northern California as project leader of a graphic company called CALMA. . . . **Joshua Persky** is writing fiction about the fear of nuclear war, and he plans to hang out in Jerusalem and write there for a few years. . . . Situated in the "depressed boomtown" of Houston are **Bob Davis,** working for DuPont, and **Bob Steinberg,** working for Texaco. I hope you guys stayed dry last summer during the storm. . . . **Jeff Tolan** spent a year as the Chemical Engineering Practice School assistant director (which believe me is a thankless job). . . . Sounding like she wishes she were a veterinarian is **Karen Hensley,** who writes, "I, of course, have a horse, two dogs and a parrot." Karen is actually doing robotics work at Carnegie-Mellon, and highly recommends the easy life for all tools. . . . **Max Klein** is living in New Jersey but makes frequent trips to Boston because "you would too if you lived in Old Bridge." . . . Finally, **Stephen Peele,** who had to chain himself to a chair in order to write us, says that he is engaged, alive and well and living in Connecticut, working for United Technologies. . . . As for me, I am also in Connecticut, but I think that everyone in the state must be married. To keep sane I do stand-up comedy, and I act in a local TV show. For a living I do technical marketing for a company called Handy and Harman.—**Lew Bender,** Guest Columnist. . . . If you want to try your hand at being guest columnist or you have any news, write.—**Chuck Markham,** Secretary, 362 Commonwealth Ave., Boston, MA 02115

82

Hello classmates! Here's the news this month. **Eduardo Moas** writes that he is now employed by United Technologies Research Center in West Palm Beach, Fla. His job involves structural analysis of advanced optics components. Believe it or not, Eduardo says he would rather be in Massachusetts for the winter. (I'll trade places with you!). . . . **Christopher Peck** (no relation as far as I know) writes, "the golden handshake from GTE Labs was too good. I'm retiring January 1 and will concentrate on new product development for Peck Development Inc. I'm having fun just contemplating my new career." . . . **Alan Peevers** is working at the Vision Lab at I.B.M.'s T.J. Watson Research Center. (There sure do seem to be a lot of classmates there!) . . . **C.J. McCracken** writes that he finished his master's in civil engineering last year and then moved with his wife, Lynn, and two sons to San Bruno, Calif., where he works for the U.S. Navy as a civil engineering corps officer. He says that the Bay area is almost as enjoyable as New England. (Take that, you California snobs!) C.J. was training for the "Ironman" Triatholon.

Richard Segal is now employed at the Wall Street firm of Salomon Brothers. He's in the bond market research area. Rich says, "The view from the top of the building is great, except for the ugly green thing in the middle of the harbor, which I think is some kind of statue." He says that amidst all the phone strikes, electric company strikes, blackouts, subway floods, and pine tar games (what are those?), New York still seems to be in only three pieces. Rich is living in "trendy" Brooklyn Heights. . . . **Jorge Herrera** writes that classmate **Lien Nguyen** married John Zayhowski last summer. Others at the wedding were Lien's best friend Karen, and Heidi and Jim Dempsey '74. They spent their honeymoon on the sunny beaches of Cancun, Mexico. Of course, Jorge didn't send any news of what he's up to, but thanks for writing anyway!. . . **Helen Fray** is currently working for I.B.M. in San Jose making thin film heads for disk drive systems. . . . Received news through the grapevine from **Philip Von Guggenberg** in Liberia, Africa. He is working for the Catholic Mission as a volunteer of the Society of African Missions Fathers. Philip is in charge of the senior sciences: biology, chemistry, and physics. In addition, he teaches one religion course. As well, he has been teaching part-time at the local technical college in the electrical and electronics department. He will be there until June, 1984.

A couple of classmates are now Bell Labs Scholars. Congratulations go to **Leah Ruby** and **Gregory Kochanski**. . . . Yours truly joins classmates **Grace Malloy** and **Lloyd Bloom** in the actuarial development program at John Hancock. I get a great view of the Institute from the top of the tower. (O.k. so it ain't exactly a rock and roll band, but a person's got to eat you know!) Write soon.—**Rhonda Peck**, Secretary, 38 Bigelow St., Cambridge, MA 02139

83

Hello fellow classmates. This is our first appearance in *Technology Review*. The purpose of this column is to relay accomplishments and activities of fellow members of the class of 1983.

I haven't received many letters so I thought I would use this issue to congratulate some individuals for their accomplishments since last spring. **Dennis W. Ward** and **Fred D. Allen** received minority service awards. **Susan D. Flynn** won the New England Regional A.I.Ch.E. Student Chapter Conference award. **Sarah E. Bingman** was awarded a special service award for exceptional contributions to departmental activities. **Ivan Fong** won the Robert T. Haslam Cup for outstanding professional promise. Ivan was also elected to the M.I.T. Chapter of Phi Beta Kappa, along with **Ali Borhan**.

John Piotti received the Dean A. Horn award through the M.I.T. Sea Grant Program. **James E. Colgate** won the Admiral Luis de Florez prize in the Department of Mechanical Engineering for "outstanding ingenuity and creative judgment." **Neil C. Singer** won a $250 mechanical engineering award for his programmable parts feeder design. **Akwete Akoto** won a $125 mechanical engineering award for his inverted pendulum.

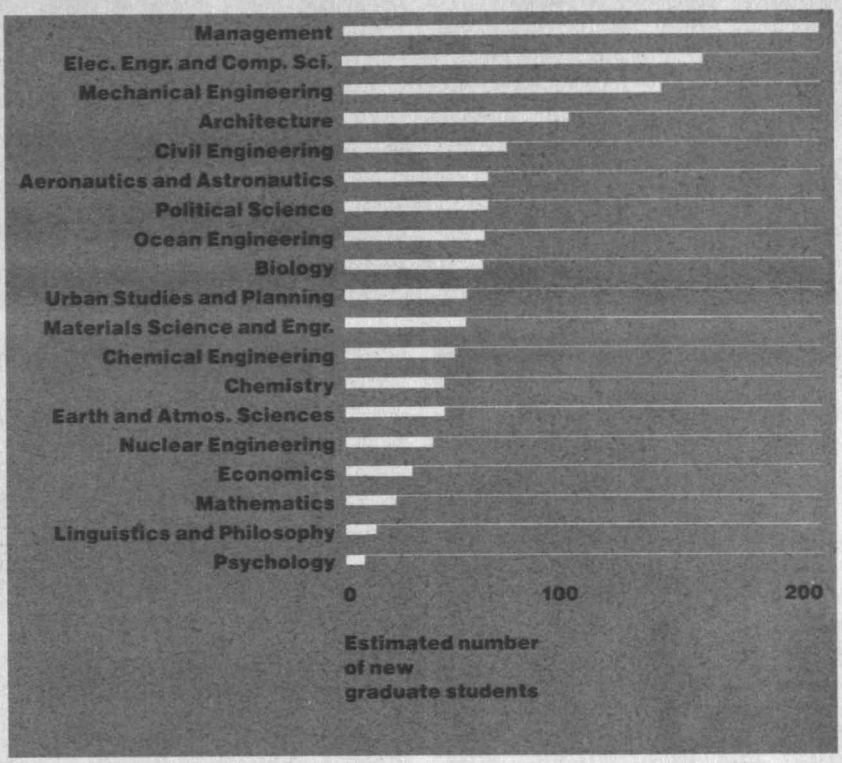
Four members of the Class of 1983 were honored simultaneously for their work in the chemistry department: **Donald J. Schumacher, Robin K. Hoe, Raymond E. Goldstein** and **Louis J. Terminello**. **Hank J. Bromley** won an Austin Kelly prize for excellence in humanistic scholarship. **Greg A. McAllister**, from the mechanical engineering department won the $5000 Henry Ford II Scholar Award. . . . R.O.T.C. performers were also honored last spring. Army Cadet **Hilton C. Russell** won the General Leslie Groves award, and Navy Midshipman **Joe Masci** received the Admiral Edward Cochrane award.

The National Women's Championships last spring was also the site of some fellow 1983 accomplishments. M.I.T.'s varsity four placed third overall. In that standout shell were three members of our class: **Laura Kiessling** (bow), **Liz Bradley**, and **Lillian Hill** (stroke). . . . **Jennifer R. Melcher**'s thesis was selected by the department of electrical engineering as the best undergraduate thesis in the department. **Jean-Jacquea J. Hajjar** was second while **John W. Webster III** won third. **Peter J. Osler** won the top thesis award for computer science.

Well, that about raps up all I know about everyone's awards. As for other news, I heard **Paul Neves** did well over in Europe this past summer competing in track. As I understand, he took second overall and first for the U.S. Good job, Paul! I ran into **Ken Dumas** and **Hyuna Park** out in front of the student center. The two young entrepreneurs were still out trying to capitalize on Hyun's M.I.T. T-shirt design. Both Ken and Hyun expect to graduate this year. As for myself, I'll be at the Sloan this year and then I'll get out in the real world and start playing around.

I am really interested in what everyone is up to. If you are, or know of someone who is, doing something new and exciting, or maybe boring and commonplace, then write to me.—**John E. De Rubeis**, Secretary, 86 Mount Vernon, Boston, MA 02108

New Graduate Students



While the 1,070 new freshmen tended to take the spotlight (pages A4-A13), 1,400 new graduate students also were finding their way through the labyrinth of M.I.T. this fall. The chart shows each department's estimates as of midsummer; final registration figures remained unavailable as this issue went to press.

I

Civil Engineering

Hugh G. Robinson, S.M.'59, has been appointed to head the Southland Corp.'s, Dallas, Tex., 120-acre real estate development project at North Central Expressway (located northeast of downtown Dallas). He will be responsible for the direction of the mixed-use real estate development Southland plans over the next 15 to 20 years, which will include office and retail space, hotels, and residential areas in a park-like setting.

Leonardo Miranda, S.M.'66, who joined the U.S. Air Force in 1963 and was discharged in 1971 with the rank of captain, passed away on May 17, 1983. During his career with the Air Force he received the Good Service and Commendation Medal for his work as an aerospace facilities engineer in the Space and Missiles Organization. He later joined the Naval Air Rework Facility, North Island, Calif., serving as an aerospace facilities engineer. Miranda's work brought him in frequent contact with the Defense Department and he received many awards for meritorious service from the United States government.

Theodore F. Mariani, S.M.'57, president of Mariani and Associates, Inc., Architects, Engineers and Planners, Washington, D.C., has been elected a national vice-president of the American Institute of Architects. . . . **Wallace E. Walker,** S.M.'73, reports that he is currently a permanent associate professor in the Department of Social Sciences at West Point.

II

Mechanical Engineering

M.I.T.'s research in the economics and technology of railroads has been designated part of the Association of American Railroads' "Affiliated Laboratories" program. The idea, says William J. Harris, Jr., AAR vice-president for research, is to assure "continuing involvement of students and faculty on research efforts in areas of benefit to the industry." Three other institutions were also listed: Carnegie-Mellon, the University of Illinois, and Illinois Institute of Technology, where AAR will participate in a joint Laboratory for Railroad Research. Professor **David Wormley,** '62, is program director for the AAR Affiliated Laboratories activities.

Henry A. Morgan, Jr., S.M.'66, has been appointed Stone & Webster Engineering Corp.'s project manager for the Clinch River Breeder Reactor Plant Project, Oak Ridge, Tenn. The project is the nation's first large-scale liquid metal fast breeder reactor demonstration plant. . . . **John A. Welsh,** '55, director of the Caruth Institute Business School at Southern Methodist University, has been named a director of Syntech International, Inc., Dallas, Tex.

III

Materials Science and Engineering

John F. Elliott, Sc.D.'49, director of the Mining Minerals Resources Research Institute at M.I.T., where he is American Iron and Steel Institute Distinguished Professor has been named a fellow by the American Institute of Chemical Engineers. He was chosen "for his outstanding contributions in research, consulting and education to the field of metallurgical engineering."

Michael D. Rinaldi, Ph.D.'66, who has been working in metallurgy at the General Electric Co., Lynn, Mass., since 1971, has recently moved into manufacturing organization—focusing on application of computers to the manufacturing process.

Eldon N. Dunlap, Sc.D.'36, a retired Chevron Oil executive, passed away on November 30, 1982. His career began in 1933 with Humble Oil in east Texas, and he then moved to Standard Oil Co. of Texas (now Chevron) in 1942. In 1951 he transferred to Chevron's west division in Denver, Col., where he held several supervisory posts, until his retirement in 1976. Dunlap was a member of the Legion of Honor of the American Institute of Mining Engineers, and of Tau Beta Pi.

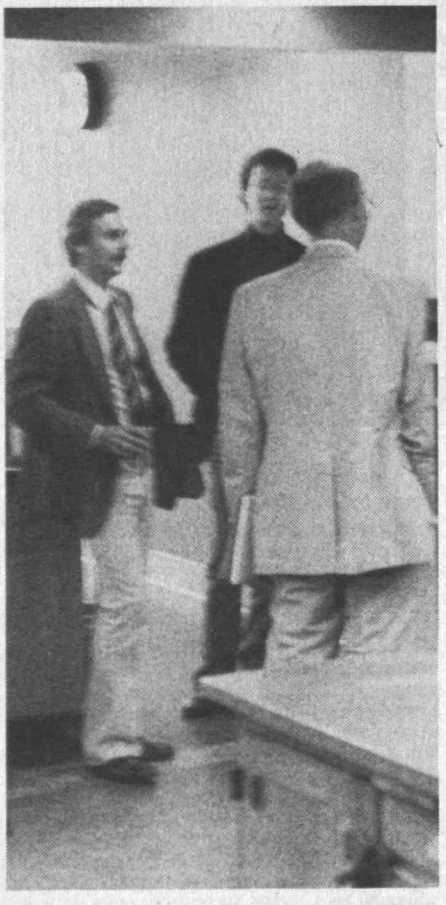
V

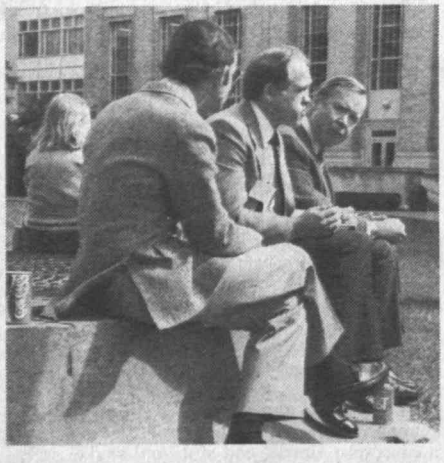
Chemistry

Professor **Mark S. Wrighton** of M.I.T. is consulting editor of *General Chemistry* (Houghton Mifflin), a new text by Professor Darrell D. Ebbing of Wayne State University. Their goal: to present students "with the chemistry worth knowing and encourage them to learn and to apply the basic concepts of science."

Gordon G. Hammes, who was a member of the M.I.T. faculty from 1960 to 1965, is now director of the biotechnology program at Cornell University. He's been at Cornell since leaving the Institute, achieving international recognition for thermodynamic, kinetic, and structural studies of the regulation of biological processes by enzymes.

Fall sunshine lured members of the M.I.T. Chemists Club into the Eastman Court for a picnic buffet on September 24. The morning was devoted to formal presentations, the afternoon to tours (center, left) of the new undergraduate laboratories in Building 4.





Chemistry: Turning Toward Undergrads

Five Issues on Chemistry Educators' Balances, Says Dean Deutch

Reconstruction of the undergraduate chemistry laboratories on the fourth floor of Building 4 was completed early last fall—visible evidence, says John M. Deutch, '61, dean of the School of Science, of the Chemistry Department's new emphasis on undergraduate education.

Back for the first convocation of the M.I.T. Chemists Club, some 50 Course V alumni—many of them knew every chip and crack in the old lab, a landmark since 1916 when M.I.T. moved to Cambridge—cheered the new $2.1 million facilities and the program they manifest on September 24.

As an example of the department's new thrust toward undergraduate education, Professor Mark S. Wrighton announced the introduction of a new course—5.912—to the undergraduate program this fall. It's a seminar program designed to acquaint chemistry majors with M.I.T. research activities and career possibilities—a new mechanism for camaraderie among chemistry majors and one-on-one interaction between students and faculty.

Five issues of balance confront the department—and chemistry educators everywhere—as they develop plans for the 1980s, Dean Deutch told the convocation;

☐ Balance between the graduate and undergraduate programs. While graduate students follow the specialized programs of research within the department, undergraduate students should be motivated to prepare for the broadest possible opportunties in the field. The fact that students tend to repeat the careers of role models they find in the department makes especially important the faculty's wisely choosing its topic for research.

☐ Balance among sub-disciplines of the field. Current emphasis is on the traditional fields of organic, inorganic, and physical chemistry. But this traditional emphasis may be too narrow. Should the department expand to other fields such as applications of chemistry to the earth sciences, brain chemistry, or polymer science?

☐ Balance between pure and applied chemistry. Especially in the United States, the lines between the pure sciences and engineering are drawn only vaguely. There seems now to be less interest in research in the pure sciences; but the emphasis on applications can easily become excessive, especially in fields such as biotechnology and environmental studies.

☐ Balance between theory and experiment. Departments have a tendency to emphasize the study of theory rather than to engage in experiment. The

reason is quite simple: experiments are more expensive, for they require expensive instrumentation, space, and other resources.

□ The balance between academic and industry. The longstanding university-industry relationship is usually justified as economic necessity. But close collaboration, has many less tangible advantages and continuing study is needed of the implications of educational and research relations between the Institute and industry.

The Chemistry Department's goal remains, said Dean Deutch: to carry out forefront research in the field and to provide an outstanding education for young people who will eventually have leading roles in the profession and in the industry built on it, as teachers, researchers, and managers.

The Chemistry Department faculty has traditionally functioned toward these goals. Remembering his own experiences while a Course V undergraduate student, Professor Walter H. Stockmayer, '35, who has recently retired at Dartmouth, cited Professor Avery A. Ashdown, '24, who "lived and breathed M.I.T. as he dedicated his life to pure research" and Professor Eugene Rabinowitch whose scope of expertise encompassed chemistry and Russian poetry. Professor Stockmayer encouraged the members of the Chemists Club to extend their interest to vital social issues while persevering in their own field.—*Elizabeth Motzkin*

"The Chemistry Department's goal remains, said Dean Deutch: to carry out forefront research in the field and to provide an outstanding education for young people . . ."

Walter H. Stockmayer, Ph.D.'35, Albert W. Smith Professor of Chemistry emeritus at Dartmouth College, Hanover, N.H., received an honorary doctor of humane letters degree from the college at its commencement exercises last spring. For 22 years he has been on the Dartmouth faculty as teacher of physical chemistry and research scientist with expertise on the quantum mechanics of polymers. "You represent in the finest sense that for which a liberal arts college stands," said the citation. Formerly Stockmayer was professor at M.I.T. for 20 years. . . . Ripon College's Chemistry Department, Ripon, Wis., headed by **James W. Beatty,** Ph.D.'60, has been designated a Commodore Education Resource Center. Under the program Ripon will receive computer software and other services to strengthen computer-assisted instruction. But Beatty emphasizes that the department's eight microcomputers "are not going to replace the instructor." . . . **A. Truman Schwartz,** Ph.D.'63, professor and chairman of chemistry at Macalester College, St. Paul, Minn., has been named a DeWitt Wallace Professor. Selection to the professorship is on the basis of teaching effectiveness, professional competence, intellectual growth, and service to the College and the wider community.

VI

Electrical Engineering and Computer Science

A cyclo-inverter system that permits a three-phase single-speed induction motor to be converted economically to two-speed operation has won a prize for **Bradford Howland,** a graduate student in the department; and its first application at M.I.T. is expected to save the Institute over $4,000 a year in energy costs. The $2,500 prize is from the National Association of College and University Business Officers, supported by the United States Steel Foundation. The M.I.T. application is on the supply and return fans of the central air conditioning system in Building 53. **Carl W. Hagge,** '57, M.I.T.'s environmental engineer, says the system has potential for any situation "where low speed is adequate for a significant number of operating hours."

A grant from Kokusai Denshin Denwa Co., Ltd., Tokyo, will make possible the KDD Center Development Professorship in Communications and Technology at M.I.T., intended for a junior faculty member whose work focusses on modern communications.

Three Institute laboratories in electrical engineering have been consolidated into a new Laboratory for Electromagnetic and Electronic Systems under the direction of Professor **Thomas H. Lee,** Philip Sporn Professor of Energy Processing. The three: the Continuum Electrodynamics Laboratory, the High-Voltage Research Laboratory, and the Electric Power Systems Engineering Laboratory, of which Professor Lee was formerly director. **James R. Melcher,** Ph.D.'62, Stratton Professor of Electrical Engineering, is associate director.

George Wayne, S.M.'48, president of Gentest, Inc., has presented President Paul E. Gray, '54, with a check covering a $150,000 fee under an agreement by which his firm will receive a limited-term license to three existing patents and two pending disclosures relating to mutation assays. In addition, Gentest will sponsor research in the laboratory of **William G. Thilly,** '67, associate professor in the Department of Nutrition and Food Science at M.I.T. . . . **Martin L. Baughman,** Ph.D.'72, associate director of the Center for Energy Studies and associate professor of electrical engineering at the University of Texas, Austin, has taken a one-year leave of absence to perform consulting work in the field of electric power modeling. . . . **Martin W. Essignmann,** S.M.'47, who retired last year as professor of electrical engineering at Northeastern University, was awarded an honorary doctor of engineering degree from the university last June. During 40 years faculty member Essignmann

served briefly as a visiting instructor and assistant professor at M.I.T., and he was dean of research at Northeastern for 19 years starting in 1961.

Theodore M. Burkholder, S.M.'24, founder and president (for 46 years) of the former Powrex Switch Co., Watertown, Mass., passed away on August 4, 1983. During World War II, he joined the Raytheon Co., Waltham, Mass., in the Power Tube Division as a radar production engineer, retiring in 1964 and disbanding his own business in 1975. He was inventor and producer of special mercury switch relays used in industrial electrical controls to turn moving circuits on and off.

Four alumni are among the authors of two new books in the field of computer science and artificial intelligence that appeared this summer under the imprint of the M.I.T. Press: **John M. Hollerbach,** Ph.D.'78, **Timothy L. Johnson,** '69, and **Matthew T. Mason,** '63, of *Robot Motion: Planning and Control;* and **Robert C. Berwick,** Ph.D.'82, of *Computational Aspects of Discourse.*

Martin Patt, S.M.'64, has been promoted from assistant professor of electrical engineering to associate professor at the University of Lowell, Mass. . . . **John V. Harrington,** Sc.D.'58, senior vice-president of research and development and director of COMSAT Laboratories of the Communications Satellite Corp., was the recipient of the Cooper Union's Gano Dunn Award. The award is the highest honor that the Cooper Union Alumni Association bestows for oustanding professional achievement in science and engineering; Dr. Harrington was cited for important contributions to the field of satellite technology. . . . **Ronald W. Schafer,** Ph.D.'68, McCarthy/Audichron Professor at the Georgia Institute of Technology was honored by the South East Region of Electrical and Electronics Engineers with its Outstanding Engineer Award.

Edward E. David, Jr., Sc.D.'47, president of Exxon Research and Engineering Co., Florham Park, N.J., has been named the 1983 Medalist by the Industrial Research Institute. The award recognizes "outstanding accomplishments in leadership or management of industrial research which contributes broadly to the development of industry and to the benefit of society." . . . **William R. Hewlett,** S.M.'36, has been re-elected chairman of the board of Carnegie Institution of Washington, for an additional three-year term; and **Edward E. David, Jr.,** Sc.D.'47, has been elected (for the first time) as a trustee to the executive committee for a one-year term.

Elazer R. Edelman, S.M.'79, has received a 1983-84 Surdna Foundation Predoctoral Fellowship. The fellowship has been created for students working toward Ph.D. and Sc.D. degrees at M.I.T.'s Whitaker College of Health Sciences, Technology, and Management. . . . **James Jursik,** S.M.'53, writes, "I work for IBM, Rochester, Minn., managing a small group responsible for the design of custom integrated circuits for use in magnetic disc files and also do software development for the purpose of design productivity and design integrity." . . . **William E. Leonhard,** S.M.'40, has relinguished his presidency of Parsons Corp., Pasadena, Calif.; he continues as the firm's chairman and chief executive officer. **Otha C. Roddy,** S.M.'51(X), formerly president of the subsidiary Ralph M. Parsons Corp., has succeeded Leonhard as president of the parent company. . . . **Owen W. Kennedy,** '59, professor (since 1965) of electrical engineering at Worcester Polytechnic Institute, has been appointed associate head of the department.

VI-A Program

This June, 109 students joined the VI-A Program—the largest entering class in the program's 66-year history. Total entrollment this past summer was 269. Forty of these VI-A students were at west coast companies in the Silicon Valley area of California.

The annual West Coast VI-A picnic, organized by the students, was held on August 14 at Ortega Park, Sunnyvale, Calif. A larger number of alumni/ae attended this years' picnic than in the recent years, and we were glad to greet the following: **Peter B. Ashkin,** '73 (with Zilog) and wife Marti with their twins; **Allen J. Baum,** '73 (with Hewlett-Packard Co.); **Eric D. Black,** '77 (with Gould, Inc.); **John F. Cooper,** '74 (with Dolby Labs, Inc.); **J. Payne Freret, Jr.,** '68 (with Ungermann-Bass, Inc., Santa Clara, Calif.) and Payne's wife **Lynn M. Roylance,** '72 (with Hewlett-Packard Co.); **Mark T. Fuccio,** '80 (with Trilogy Systems Corp.); **Paul E. Stoft,** '49 (with Hewlett-Packard Co.) and wife; **Kenneth A. Van Bree,** '71 (with Hewlett-Packard Co.); and **John D. Williams,** '76 (who will be attending Stanford Medical School this fall). Also attending was Professor **Carl E. Hewitt,** '67, who had accompanied Mr. Tucker on his VI-A business trip.

Some 20 VI-A students working at the four Bay Area companies (Fairchild, Hewlett-Packard, IBM and Xerox) also came to the picnic.

Continuing a tradition at Texas Instruments, Inc., **Cecil H. Green,** '23, hosted the eighth VI-A luncheon at the Petroleum Club, Dallas, Tex, for TI executives and VI-A students and their managers. This year **Dolan McDaniel,** president, Geophysical Services, Inc., and Robert Graebner, GSI vice-president, also attended. GSI is the parent company of TI, Inc.

VI-A alumni attending the TI luncheon who are also TI employees included: **Keith A. Blanton,** '78; **Dean R. Collins,** '58 (TI's VI-A coordinator); **William Dockendorft,** '82; **Steven D. Krueger,** '79; **Hung P. Le,** '81; and **Dale E. Zimmerman,** '81.

Following custom, Mr. Green spoke about his days in VI-A and philosophized on the advantages of being enrolled in the VI-A program. He then called upon Director Tucker who presented an update on the growth of the program and its relation to the department's curriculum and thanked the managers for their continued support. Finally, each student was asked to briefly describe his assignment and to "make any other comments they deemed appropriate." A number thanked Mr. Green and TI for the opportunities provided them and the experience they had gained.

It is worthy of note that a new joint professional chair has been established in M.I.T.'s Department of Nutrition and Food Science and the Whitaker College of Health Sciences, Technology and Management. The Poitras Professorship in Medical Engineering was established from a grant from the late **Edward J. Poitras,** '28, a course VI-A graduate, and is named for his wife **Dorothy W. Poitras. Robert S. Langer, Jr.,** associate professor of biochemical engineering, is the first to fill this chair. Ed Poitras did his VI-A work at the General Electric Co. and later became famous for his involvement with the building of the "Mt. Palomar 200" telescope where he was in charge of designing the servo controls for that mammoth machine.

John Tucker was a guest at a gathering at the home of **Geoffrey J. Bunza,** '74, on July 24. Also attending was **Steven L. Bates,** '74 and his family. Both Geof and Steve now work at GenRad where Geof is product line manager; he is also vice-chairman of the IEEE Worcester section. Visitors to the VI-A office have included: **David E. Abrams,** '76; **Robert L. Baber,** '58, of Bad Hamburg, Germany; **John V. Burroughs,** '82, who is with Data General; **Peter H. Dinnerstein,** '81, of Redondo Beach, Calif.; **Daniel M. Sable,** '80, of Plainsboro, N.J.; **Bernard I. Szabao,** '81, of Bethesda, Md.; **Margaret (Rondio) Turek,** '72, her husband **Robert F. Turek,** '70 and their children from McLean, Va.; and **John A. van Raalte,** '59, of RCA Laboratories, Princeton, N.J. We also recently had a call from **Theodore T.S. Wong,** '73, who early in 1983 joined Judson Infrared, Inc., Montgomeryville, Penn., where he is vice-president of research and development and engineering.—John A. Tucker, Director, VI-A Program, M.I.T., Room 38-473, Cambridge, MA 02139

VII
Biology

Nigel M. Crawford, who's just received his Ph.D. from the department at M.I.T., is among 24 winners of the first fellowships in a new program in plant biology from the National Science Foundation. Dr. Crawford will go to Stanford to study genetic events in the corn cell—a switch from his work with Professor David Baltimore on the mechanism of replication of the polio virus.

Leland Harrison Hartwell, Ph.D.'64, professor of genetics at the Univeristy of Washington, Seattle, is the recipient of a Guggenheim Fellowship to study "Identification for the Yeast Hormone Receptor." An authority on molecular biology, he has been with the faculty since 1967 and has developed a research program on cell division in yeast that is attracting world-wide attention.

VIII
Physics

Professor **June L. Matthews,** Ph.D.'67, is on leave from the department at M.I.T. to serve as professor of physics at her alma mater, Carleton College (Northfield, Minn.)

Robert E. Stoeckly, '60, reports, "I have accepted a new job as a member of the technical staff at Kaman Sciences Corp., Santa Barbara, Calif. My wife and I have a daughter, age three." . . . **Herbert Goldstein,** Ph.D.'43, professor of nuclear science and engineering at Columbia University (since 1961), New York City, noted for his scholarship on classical mechanics and reactor shielding, has been named the first holder of the new Thomas Alva Edison professorship at the university. The Edison Professorship for energy research was established with a gift of $1 million from Con Edison last November.

David S. Saxon, '41, chairman of the M.I.T. Corporation, is now a member of the Corporation of the Woods Hole Oceanographic Institution, Woods Hole, Mass., and **Dayton H. Clewell,** Ph.D.'33, of Darien, Conn., has been named an honorary member.

Robert F. Benjamin, Ph.D.'73, of the Shock Wave Physics Group at Los Alamos National Laboratory, is credited with a new method of quickly detecting shock fronts that result from surfaces moving at high velocities. The scheme involves a microballoon filled with xenon or argon glued to one end of a fiber-optic cable. As a shock front compresses the microballoon, the gas inside is compressed to produce a tiny flash. The flash is transmitted by the optical cable to a camera or other detector.

Angelo R. Del Campo, S.M.'48, of Highland Beach, Fla., passed away on January 23, 1983; no details are available.

IX
Psychology

Professor Nelson Y.S. Kiang, whose first appointment at M.I.T. was with Professor **Walter A. Rosenblith** in the Research Laboratory of Electronics, is now Eaton-Peabody Professor of Communication Sciences, an appointment shared between this department and the Whitaker College of Health Sciences, Technology, and Management. Dr. Kiang is a leading expert on the neurology of hearing, and his new appointment is designed to formalize a new research and teaching relationship between M.I.T. and the Eaton-Peabody Laboratory of Auditory Physiology at the Massachusetts Eye and Ear Infirmary, of which Dr. Kiang has been director since its founding in 1956.

X
Chemical Engineering

Professor **Jack B. Howard,** a member of the faculty in the department at M.I.T., has been named the 1983 recipient of the Henry Storch Award of the Division of Fuel Chemistry of the American Chemi-

cal Society. He was cited for work leading to a better understanding of the chemistry, physics, and engineering of coal at high temperatures. . . . **Geoffrey A. Russell,** S.M.'69, writes, "After leaving the 'Tute, I worked for Exxon for three years in New Jersey, Louisiana, and Venezuela, then went to graduate school in materials science and engineering (polymer physics) at the University of Utah. Upon receipt of my Ph.D. in 1977, I took a job at the Kodak Research Laboratories, Rochester, N.Y. Linda and I have one son Jared (age two) and a Norwegian Elkhound," and at the time of this writing, they were expecting a second child. . . . "but no more Elkhounds," Geoffrey said.

Christian W. Knudsen, Sc.D.'69, is currently a technical director at Scientific Design Co., Houston, Tex., working on synfuels, cogeneration, and enhanced oil recovery. . . . **Charles P. Marion,** Sc.D.'52, has been appointed chief technologist at the Texaco Development Corp., Harrison, N.Y., the patent and licensing subsidiary of Texaco, Inc. Upon graduation from M.I.T., he joined Texaco as a chemical engineer in the U.S. Refining Department, Montebello, Calif, and in 1962 joined TDC as a representative in New York, being named manager of process licensing in 1980.

XI

Urban Studies and Planning

Members of the M.I.T. department were active in two Boston-area projects during the summer of 1983. They've provided staff support to a Copley Square Centennial Committee which seeks the redesign of that Boston landmark, and **J. Mark Davidson Schuster,** lecturer in the department, was a major participant in a study of issues in financing of museums. Entitled *Patrons Despite Themselves: Taypayers and Arts Policy,* the study proposes that public funds are used to support the arts without the knowledge of most taxpayers, and the policies of arts institutions are heavily influenced not by these taxpayers but by an elite group of wealthy patrons.

Theodore C. Landsmark, who was a member of the M.I.T. faculty and associate director of the Community Fellows Program from 1979 to 1982, is now dean of graduate and continuing education at the Massachusetts College of Art, Boston. In addition, he'll continue the practice of law that he opened in 1980. Landsmark has been president and chief executive officer of the Black Oak Corp., a management consulting firm in the field of construction management and real estate development, since 1982 and lecturer in the University of Massachusetts' Law and Justice Program since 1981. At the same time, he has served as president of the Artists' Foundation, providing grants and technical services to artists in Massachusetts, and founder and director of Alchemie, a nonprofit art gallery in Boston's Fort Point Channel financial district. Landsmark is the author of a study funded by the Department of Housing and Urban Development on the development of artists' living and working spaces and has advised Boston artist groups on loft space issues.

Maxine V. Mitchell, M.C.P.'73, a senior vice-president for Comprehensive Marketing Systems, Chicago, Ill., has recently been elected a trustee of Emma Willard School, Troy, N.Y., a private college preparatory school for girls in grades 9 through 12.

XII

Earth, Atmospheric, and Planetary Sciences

Stewart Nozette, Ph.D.'83, who moved to Southern California early last spring, has wasted no time in organizing a new program in space development at Scripps Institute of Oceanography. He was coordinator of a Scripps conference on "Low-Cost Approaches to Space Exploitation" early in October at which **Frank P. Davidson,** head of the Macroengineering Study Group at M.I.T., was a speaker.

Henry and Elizabeth **Stommel** are the authors of *Volcano Weather–the Story of 1816, the Year Without a Summer* a description of the explosive eruption of Mount Tambora in 1815 and its effects on Northern Hemisphere weather. . . . **Nathaniel M. Sage, Jr.,** Ph.D.'41, reports, "Just retired on June 26, 1983!"

XIII

Ocean Engineering

Harold L. Young, S.M.'60, a rear admiral in the United States Navy has left his post as supervisor of shipbuilding, conversion and repair at the Naval Submarine Base, New London, Conn., to become deputy commandar for submarines in the Naval Sea Systems Command Headquarters, Washington, D.C. . . . **Robert C. Sprague, Sr.,** S.M.'23, founder of the Sprague Electric Co., has been presented the 13th annual Francis H. Hayden Memorial Award by the Northern Berkshire (Mass.) Chamber of Commerce. The award honors a North County resident who has contributed to the economic, social, and cultural betterment of the area. Sprague has been a director and trustee of many organizations in the area. He also holds several honorary degrees from New England universities and has twice been the recipient of the Electronic Industries Association's Medal of Honor Award.

Lawrence K. Donovan, S.M.'71, writes that he has taken command of the Chesapeake Division, Naval Facilities Engineering Command, Washington, D.C., responsible for all Navy and Department of Defense construction and facilities management in the area.

XV

Management

Professor **Lester C. Thurow,** whose *The Zero-Sum Society* is hardly off the best-seller lists, is now the author of *Dangerous Currents: The State of Economics* (Random House, $16.95). It's an attack on conventional academic theory as embodied in what Thurow calls the world of *Homo economicus,* suggesting emphasis on new economic models that "better reflect the world as we can see and measure it and also enhance possibilities of exercising economic control."

Business Planning for an Uncertain Future (Pergamon Press) is the title of a new book by **Roy Amara,** '48, and Andrew Lipinski of the Institute for the Future. "A practical guide . . . on how to use both hard and soft information, how to develop new options that deal with uncertainty, and how to use operational experience to judge how organizations will respond to new directions."

Harry Katz, associate professor of industrial relations at the Sloan School, was a principal speaker at The Conference Board's first annual Human Resources Outlook Conference in New York on September 27. His topic: "Where Is the U.S. Labor System Heading?"

F. Hudnall Christopher, S.M.'59, former senior vice-president of manufacturing of R.J. Reynolds Industries, Inc., Winston-Salem, N.C., is currently executive vice-president of operations for Reynolds Tobacco. . . . **Lee R. Morris,** S.M.'54, has resigned from the post of president of Wharton Econometric Forecasting Associates, Inc., Philadelphia, Penn.

Charles F. Kennedy, '36, chairman and chief executive officer of the New York State Electric & Gas Corp., Ithaca, has retired from this post but will continue as chairman of the Corporation's executive and finance committees. . . . **Richard N. Pigossi,** S.M.'65, writes, "I am regional vice-president of Private Investment Co. for Asia S.A. (PICA), a regional development finance/investment bank owned by 230 international banks and corporations. The firm is based in Jakarta and Pigossi heads PICA's operations in Indonesia, which accounts for about one quarter of PICA's activities. I have been in Indonesia for nine and a half years—the first six with the World Bank."

Gene Soltero, S.M.'66, reports that he has formed Soltero Oil Co., to conduct oil and gas exploration programs and petroleum reserves acquisition programs for individuals and corporate investors. He has been elected a director of Texas Independent Producers and Royalty Owners; a director of the Independent Petroleum Association of America; and a trustee of St. John's Episcopal School of Dallas. . . . **Scott Mason,** S.M.'72, a faculty member of the Harvard Business School since 1978 and an authority on capital markets and valuation, has been promoted to the rank of assistant professor. . . . **Dan I. Abrams,** S.M.'65, has joined the firm of Abrams & Rinehart, Inc., New York City, as a managing director. In addition, he will be chief research and investment officer and a managing director of Warburg, Pincus Counsellors, Inc., the firm's investment counselling subsidiary. . . . **John F. Fort III,** S.M.'66, president and chief executive officer of Tyco Laboratories, Inc., has been elected chairman of the firm's Board of Directors.

Sloan Fellows

David L. Chapman, S.M.'70, has been promoted from vice-president of manufacturing to senior vice-president of manufacturing at Data General Corp., Westboro, Mass. . . . **John F. Prendiville, Jr.,** S.M.'62, former vice-president—network of New England Telephone & Telegraph Co., Boston, is currently the firm's vice-president—technical planning. . . . **Ronald F. Casella,** S.M.' 72, former vice-president and head of the corporate service staff at International Business Machines Corp., Armonk, N.Y., has become president of customer service, the division of IBM based in Franklin Lakes, N.J. . . . **Winford G. Ellis,** S.M.'74, writes, "I was recently promoted to the rank of captain in the U.S. Navy. On April 13, 1983, I was relieved as commanding officer, USS *City of Corpus Christi* (SSN 705), a nuclear fast attack submarine of the 688 class. After a six-week post-command course at the Naval War College, Newport, R.I., I began my next assignment as head of the submarine, nuclear power, and strategic systems enlisted manning, Naval Military Personnel Command, Washington, D.C."

Henry E. Fish, S.M.'61, reports, "I have served as president at Amsco/American Sterilizer Co., Erie, Penn., since 1977—until January 1, 1983. At that time I became chairman and CEO, as we restructured for the future. Amsco has grown from sales of $25 million, when I graduated in 1961, to $254 million in 1982, while still maintaining our position as the leading manufacturer of hospital sterilizers, surgical tables and lights, and ancillary equipment and products. The Sloan program deserves much credit!" . . . **Albert T. Camp,** S.M.'56, writes that he is a consulting engineer to Morton Thiokol, Inc.; VSE Corp.; Plastifax Corp. of Detroit; and PRB of Belgium. He is also president of the Brentland Corp., which among other things operates the only goat milk dairy in Maryland and supplies goat dairy products to Washington and Baltimore. Camp retired from the Navy in 1980.

Leslie Clift Hruby, S.M.'73, writes, "The last year has brought a whirlwind of changes into our lives. Our wonderful daughter, Emily Rose, is now nearly a year old. My husband, Mike, is the new director of new product marketing at Foster Grant, and I've landed a new position—operations manager for the Southeast District—in the recent Digital Equipment Corp. reorganization. I also just finished my first year on the M.I.T. Alumni Association Board of Directors." . . . **Richard J. Howe,** S.M.'65, former vice-president—corporate communications and assistant to the president is now group vice-president—communications and management-support systems at Pennzoil Co., Houston.

Senior Executives

Edward E. Barr, '69, resigned in May 1982 as president and chief operating officer of the Sun Chemi-

cal Corp. to become chairman of U.S. operations of Courtaulds Ltd., England. . . . **John Owen Howell,** '67, president of the AAA Real Estate Co., has taken the additional post of president and chief operating officer of McDowell Enterprises, Inc., Nashville, Tenn. . . . **Richard Dulude,** '69, former senior vice-president and director of the Marketing and Business Development Division at Corning Glass Works, Corning, N.Y., is currently president of the firm's Electronics and Telecommunications Group.

John H. Richardson, '59, president of Hughes Aircraft Co., passed away on March 28, 1983, at the age of 60. During his 35-year career in various management positions—becoming president in 1978—at Hughes, Richardson became a leading figure in the defense industries community, testifying before Congressional committees and military panels on behalf of the Aerospace Industries Association.

Management of Technology Program

Last year's class, graduating in June 1983, found a variety of opportunities upon leaving M.I.T. **Charles Berry,** S.M.'83, sponsored in the Program by Pilkington Brothers, Ltd. in England, returned to Pilkington to become technical director of A&S Engineering in Edinburgh, a company within the Electro-Optical Division of the Pilkington Group. Charles has a B.Sc. in electronics and electrical engineering from the University of Glasgow prior to coming to M.I.T., and had been a product manager for Barr & Stroud, Ltd., another company within the Electro-Optical Division, before enrolling in the program.

John Harrison, S.M.'83, returned to Bechtel & Minerals, Inc., in Washington, D.C. A civil engineering graduate from Carnegie-Mellon, John headed Bechtel's Systems Engineering and Operations Division on the Northeast Corridor Improvement Project before coming to the program and has reentered this project since his return.

Carol Lemlein, S.M.'83, brought to the program an academic background in physics from Brown University and math from SUNY at Stony Brook. She left her position at Hughes Aircraft, where she had been developing software for missile-related control systems, and returned to California upon graduation to take a position at Teradyne, Inc. as software manager. She commented to me recently, "If you're on a technical path, it's very difficult to get the exposure in your firm to broader issues such as marketing. The program had great value to me as a broadening experience."

Hakon Myhre, S.M.'83, came to M.I.T. supported by Det Norske Veritas in Norway where he had worked in the Research Division and also on the corporate staff as a personnel manager. He had returned to the company, planning to remain on the corporate staff for two more years before moving to a line management position on the technical side of the organizaton.

The youngest member of last year's class, **Julian Nikolchev,** S.M.'83, left his position as a group leader at Anco Engineers, Inc., to come to M.I.T. Julian held degrees in mechanical engineering from Stanford (1978); he has returned to California to work as a Technology Consultant in SRI's Technology Management and Innovation Center.

Following his work at M.I.T., **Jerry Sutton,** S.M.'83, returned to the Aeronautical Systems Division, Wright-Patterson Air Force Base, where he had been a civilian systems project engineer in development planning. He's been on the road a lot since returning to Wright-Patterson, he says, visiting contractors for the B-1 project.

James Tagliaferro, S.M.'83, returned to Centronics Data Computer Corp., Hudson, N.H., in June. Jim had been a manager of test equipment engineering there before enrolling in the Program and had spent seven years with Raytheon prior to joining Centronics. Jim's undergraduate degree was in electrical engineering from Tufts University.

I.B.M. supported its first student in the Program last year. **William Vanderslice,** S.M.'83, was from the General Technology Division in Essex Junction, Vt., where he had most recently been a senior engineer managing a department responsible for the development and manufacture of semiconductor components. Bill returned to I.B.M. in New York City to be technical assistant to the director of development operations in the General Technology Division.—Jane Morse, Program Manager, Room E52-125, M.I.T., Cambridge, MA 02139

XVI

Aeronautics and Astronautics

William Denhard, S.M.'52, head of the Air Force Program Department at Draper Laboratory, Cambridge, retired on August 1, 1983. Prior to Draper's divestment from M.I.T., Denhard headed the Inertial Gyro Group of the Instrumentation Laboratory for 20 years. He plans to continue his volunteer work with his church, the M.I.T. Alumni Association, and his fraternity, and he plans to do extensive travelling and start a social service training program. . . . **Robert C. Seamans, Jr.,** Sc.D.'42, of Beverly Farms, Mass., has been elected a trustee of the Woods Hole Oceanographic Institution.

XVII

Political Science

Professor **Alan A. Altshuler,** who was a member of the department for 17 years and its head for much of that time, is now dean of the Graduate School of Public Administration at New York University. He was influential in a number of M.I.T. activities, including the International Study on the Future of the Automobile and the Undergraduate Program in Public Policy.

XVIII

Mathematics

Ravindran Kannan, who joined M.I.T. as assistant professor in the department in 1980, has been promoted to the rank of associate professor. He holds degrees from the Indian Institute of Technology and Cornell, and his work is at the interface between operations research and computer science.

Assistant Professor **F. Thomson Leighton,** Ph.D.'81, is the author of *Complexity Issues in VLSI,* scheduled for publication this month by the M.I.T. Press. It's described as solving "several mathematical problems in the areas of VLSI and parallel computation . . . in a unified and original manner accessible to anyone with an elementary knowledge of mathematics and computer science."

XX

Nutrition and Food Science

Robert S. Langer, Jr., Sc.D.'74, is now the Dorothy W. Poitras Professor in Medical Engineering jointly in the department and in the Whitaker College of Health Sciences, Technology, and Management. He's an expert in drug delivery and removal systems and in new approaches to drug development. The Poitras Professorship results from gifts of the late Edward J. Poitras, '28, and is named in honor of his widow. Mr. Poitras had been president of Fenwel, Inc., and earlier had been associated with Caltech in designing controls for telescopes at the Mt. Palomar Observatory. . . . **Dominick P. DePaola,** Ph.D.'74, has been named dean of the Dental School at the University of Texas Health Science Center at San Antonio, Tex.

XXI

Humanities

Isabelle de Courtivron, associate professor of French who is a scholar in French language and literature, has shared the first Harold E. Edgerton Award for outstanding achievement in research, scholarship, and teaching at M.I.T. She's described as "an electifying teacher. In her classes learning . . . is gaining access to another way of thinking, another mode of communicating . . ." Professor de Courtivron is a scholar of modern French literature and especially of French feminist writers, and she's the chief architect of a new curriculum in French literature and language for M.I.T. undergraduates.

XXII

Nuclear Engineering

"He's incredibly cool": his mother's comment about **Frederick H. (Rick) Hauck,** S.M.'66, pilot of the Space Shuttle *Challenger* on its second flight in July. And during the mission he was little seen by the news media: most of the attention was focussed on colleague Sally Ride, the first woman in space. Hauck was a naval officer when a student at M.I.T.; he served in Vietnam and then as a Navy test pilot before attending the Naval Post-Gradaute School in Monterey, Calif., and he was accepted as an astronaut in January 1978.

Dennis R. Spurgeon, S.M.'69, former acting chairman of United Nuclear Corp., Falls Church, Va., is now the firm's resource group vice-president. . . . **Lawrence T. Papay,** Sc.D.'69, former vice-president of the Advanced Engineering Department at Southern California Edison Co., Rosemead, Calif., has been promoted to senior vice-president. . . . **Thomas E. Murley,** Sc.D.'65, director of the Nuclear Regulatory Commission's Regional Operations and Generic Requirements Staff, Bethesda, Md., has been named regional administrator of the NRC's Regional I Office, King of Prussia, Penn.

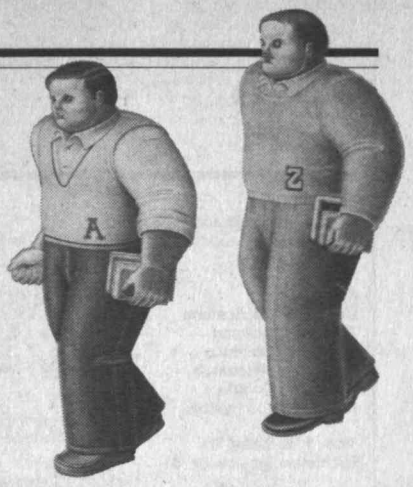
The first appointment of the W.M. Keck Professorship in biomedical engineering at M.I.T. has been made to Professor **Alan C. Nelson,** assistant professor of nuclear engineering and of health sciences and technology. Professor Nelson's work is in radiation biophysics and medical physics, the field of his Ph.D. at the University of California at Berkeley, and he is now director of the Institute's Electron Microscope Laboratory.

Gilbert Brown, S.M.'74, has been promoted to the rank of full professor of nuclear engineering at the University of Lowell, Mass. . . . **William T. McCormick, Jr.,** Ph.D.'69, president and director of American Natural Resources Co., Detroit, Mich., has taken on the additional post of chairman of ANR Production, a company subsidiary. . . . **Robert H. Wilcox,** S.M.'58, writes, "I was among those selected to receive a "Senior Foreign Service Performance Award" for my service as scientific and technological counselor at the U.S. Embassy in Mexico City during the year ending in April 1981. Since completion of my tour in Mexico, I have been associated with the Stone & Webster Engineering Corp."

Technology and Policy Program

David Cheney, S.M.'83, has joined the Library of Congress Congressional Research Service, Science Policy Research Division, as a physical science analyst. . . . **Chris Barnett,** S.M.'80, has a new position with the Fuel Charge Bureau, Department of Public Utilities, for the Commonwealth of Massachusetts. . . . **Brian Mellea,** S.M.'78, entered the Harvard Business School this past September.—Richard de Neufville, Chairman, Technology and Policy Program, M.I.T., Room 1-138, Cambridge, MA 02139

Under the Domes



The image of M.I.T. students conveyed by author Craig Vetter and his illustrator, Sandra Hendler, in Playboy for September was a little too pat for most of their Institute audience. Critics took strongest exception to Vetter's characterization of M.I.T.'s educational philosophy: "Take the strongest student and crush him. . . . Altogether," wrote Vetter, "M.I.T. tends to shatter whatever confidence its students have come in with."

The Bunny's Vision Judged too Narrow

Every writer among his readers must have admired the sleekness of Craig Vetter's *Playboy* report on M.I.T. (*"Technodarlings," September, pages 70 ff.*) and many of its images, but everyone at M.I.T. had reservations.

In a semi-official response, William J. Hecht, '61, executive vice-president of the Alumni Association, wrote Hugh Hefner, *Playboy*'s publisher, that "the portrayal of M.I.T. students is narrow, shallow, and uninvolved." And, he added, "to paint our education as crushing and one which leads to young people becoming suicidal is inaccurate in the extreme."

Reviewing "Technodarlings" in *The Tech*, David Shaw, a graduate student in management, judged that *Playboy*'s readers would be "properly awed and a bit envious" of the Institute's students

Step Back and Give Thanks

An Undergraduate's Thanksgiving Message

By Mark Templer, '84

In the hustle and bustle of our lives as M.I.T. students, we often forget the people that make our world work. Every once in a while, we should take a step back from our self-centered lives to thank the people that make the difference.

We should start with our families. They make it possible for us to be here. We can always turn to them when things get tough. And though they sometimes may not show it, they are very glad we are going a school as good as M.I.T. A parent's love is really pretty hard to beat.

Up here at school, we all have our second families, our homes away from home. We work so hard here that we sometimes forget how important our friends are. So many times they are there when we need them: after a girlfriend dumps us, after that first 22 percent on a test, during the frantic all-nighters spent finishing a term project. Many of us will never again have friendships as close as the ones we made during these college years. Long after 6.111 and thesis projects are over, we will still cherish the friends we made at M.I.T.

We at M.I.T. are also lucky to have another thing: a student community that cares. Many students put a lot of effort into the extras that make life at M.I.T. more bearable. The people in LSC, APO, house government, and even at *The Tech* make this a neat place to go to school. Our sports teams and intramurals give us a welcome diversion from our incessant tool-a-thons. And our campus' religious groups give us a chance to find God; I probably would have never found Christ had I not come to M.I.T.

There is a whole other group of people that make things work at M.I.T.: the nonstudents. Our housemasters and tutors and the administrative personnel here give their all to make things comfortable for us. Those people are the ones who make a dormitory like Baker House a great place to live. The patience and kindness of the staff and technicians of the Undergraduate Physics Office never cease to amaze me. There are a lot of people at M.I.T. who quietly perform their jobs day in and day out and get a lot of flak but very little praise from us students. But whether we admit it or not, these people make more of a difference for us than M.I.T.'s fancy labs and Nobel laureates.

And we should not forget our professors, either. Although we sometimes joke that we would like more of our classes taught in English, we really are blessed with an excellent faculty here at M.I.T. Many professors take a lot of time and effort to work with their students and get to know them. It must take a great deal of patience to explain the Poisson distribution for the 189th time to a new class of confused students, but that patience and kindness pay off in real learning. We students should be glad that some of our professors care enough to share with us so much of their knowledge and time.

Finally, we really ought to remember that all we enjoy here is possible because we live in America. The government helps many of us pay our way through school, and it pays for much of the research done at M.I.T. It also gives us the freedom to worship, speak, and live as we want—freedoms that a growing number of people on earth will never enjoy.

So before we go back to our theses and UROPs and 5.41 problem sets, let's be thankful for all we have. We are truly lucky to be where we are.

Mark Templer is a senior, majoring in physics, from Tempe, Ariz. This essay is reprinted by permission © 1983 by The Tech.

as Vetter portrayed them. But for himself Shaw was not: "If (Vetter) was interested in uncovering an accurate view of M.I.T. life, he should have ventured a little further from the center of campus, he should have talked to some underclassmen, and—perhaps most importantly—he should have interviewed some non-engineering majors."

Air and Water Sculptures

Three milestones for the Center for Advanced Visual Studies this fall:

□ "Hexagonal Rooster," a 24-foot red inflatable sculpture by Otto Piene, director of CAVS, was flown in Munich on September 24 at the third annual Sky Art Conference. And "Icarus," a sky opera of inflatables created by Piene with CAVS fellows Paul Earls and Ian Strasgogel, was performed on several occasions during the meeting. Professor Piene is credited with starting the sky art movement, and he had a prominent role in the conference.

□ "Aqua-Mirage," a proposal for a water sculpture by CAVS fellows Joan Brigham and Paul Earls, was one of 13 winners in an international water sculpture competition conducted by the 1984 Louisiana World Exposition.

□ Works by Todd Siler, CAVS fellow, were exhibited at the Ronald Feldman Gallery in New York during the early fall, and a larger collection of Siler's work opened in M.I.T.'s Compton Gallery in October. Additional work—a col-

Course 6.001—Structure and Interpretation of Computer Programs—was given last summer for 51 members of the M.I.T. faculty, including Provost Francis E. Low (left) and Professor James W. Mar, '41. The idea was to bring its faculty-member students up to speed in a field that literally didn't exist when they went to school. (Photo: Calvin Campbell)

This 24-foot-high inflatable sculpture —"Hexagonal Rooster"— by Otto Piene, director of the Center for Advanced Visual Studies, was the hit of the day when flown this fall at the third Sky Art Conference in Munich. (Photo: William H. Coderre, '85)

lection designed to elicit observers' thoughts on the process of thinking, is in the M.I.T. Neuroscience Research Center. *Omni* describes Siler's work as "remapping the boundaries between the aesthetic and the cerebral cortex."

Philosophy Professorship

A gift from Laurance S. Rockefeller to fund the Rockefeller Professorship in Philosophy came to M.I.T. during the summer—a new resource that will be "of inestimable value to the . . . emerging collaboration between philosophers and scholars in other disciplines" at M.I.T., said President Paul E. Gray, '54. It's the second professorship given by Rockefeller; the first was the Abby Rockefeller Mauze Professorship to honor the donor's sister.

New Focus on the Brain

No one doubts the complexity of the human brain. But don't be put off by that, said Professor Francis Crick of the Salk Institute for Biological Studies in a lecture at M.I.T. last fall. "We must try to think in which way we can most easily penetrate" this system, he said, and he encouraged M.I.T. to be "a center for this strongly directed approach. You are in a very enviable position."

"Pure coincidence" that Crick had spoken this way, said Dr. Emilio Bizzi, director of the Whitaker College of Health Sciences, Technology, and Management. Bizzi himself during the summer had announced plans to add to Whitaker's present activities a new program of education and research in

brain science. "Better understanding of the brain and nervous system will enable us to understand what makes us human," he said.

Aquino Mourned

The death of Benigno S. Aquino, Jr., the Phillipine opposition leader killed on his return to Manila in the fall, had special meaning at the M.I.T. Center for International Studies: Aquino had been a visiting scholar there during 1982-83, working with the Far Eastern studies group. Professor Eugene B. Skolnikoff, '49, director of the Center, described Aquino as "a rare individual—intelligent, warm, and dedicated. He made many contributions, and many friends," Skolnikoff said.

Week-Long Mexican Fiesta

The 36th annual M.I.T. Fiesta in Mexico will be extended to seven days—March 16 through 23—in 1984. The group will gather in Mexico City on March 16, traveling to Morelia by bus on March 18 and to Guadalajara on March 21. Morelia is among the gems in Mexico's colonial highlands, and Guadalajara, the second largest city in Mexico, is famed for its craftsmen and artists. Arrangements are being completed by Rogelio Moreyra Sandoval, '78, president of the M.I.T. Club of Mexico, and further information is available from Joseph J. Martori, associate secretary of the Alumni Association, Room 10-115, M.I.T.

Alumni Relations Changes

Janet S. Lambert has joined the Alumni Association staff in a new post—director of course programs. Her responsibility: to strengthen Alumni Association services to the 40 percent of M.I.T. graduates who are alumni of the M.I.T. Graduate School.

Other recent changes affecting alumni relations activities: D. Hugh Darden, formerly director of the Office of Planned Giving, now has a new title—assistant treasurer—but works in the same area of responsibility. And Thomas R. Henneberry, formerly associated with Darden, is now in charge of Institute insurance and legal affairs.

$1.65 Million for Sea Grant Research

Sea Grant support for research, education, and advisory services at M.I.T. in 1983-84 is $1.65 million, and most of it will be devoted to work in five areas: unmanned underwater work vehicles, offshore engineering, coastal processes, ocean resource utilization, and other technology for ocean uses.

Diana ben Aaron
continued from page A2

As a corollary to the popular appearance of the lab, I offer the stereotypical appearance of the person who works there. Not only is he an absent-minded genius, but he lives at the lab and consequently never removes his lab coat. (Jacket and tie allowed for conferences, desk work, and nuclear reactor openings; shirtsleeves permitted at Los Alamos and points west and for informal portraits in *Omni*; turtleneck for popular—i.e. Walt-Disney-level—astrophysicists only.) The popular image has it that, although the word "laboratory" comes from the Latin meaning "work," scientists find their jobs fun, even treating them as extensions of childish inquisitiveness.

At my lab (note possessive indicating personal involvement; the feeling of having a stake in the project comes almost automatically), most of us do enjoy our work, but we do not treat it lightly. We are all a bit relieved at the end of the day, just like any other workers. I have yet to see anyone wear a lab coat in our lab. If we did, it would be for the same reason we use gloves and I sometimes wear an apron: self-defense—not show. Far from being narrow-minded and one-sided, we represent a broad spectrum of the Institute community. (Statistics favor diversity in research groups; about two-thirds of all M.I.T. students work in labs at some point during their time here.)

Scientists as Craftsmen

To attack another misconception: the greatest dangers facing most scientists are forms of physical injury through carelessness, not moral dilemmas (although those can be frightening, too). Many rooms have radiation or biohazard signs. Everyday laboratory procedures almost everywhere involve some hazard. Sterile areas in biology buildings keep mutant strains confined as well as keeping contamination out. A mechanical engineering lab routinely machines an epoxy whose powder is fatal when inhaled in large quantities. I often make up acid, cyanide, and hydrogen fluoride solutions. The last two are lethal under the right conditions, and the right conditions are surprisingly easy to produce by accident.

But despite the danger, the tedium (the work has no end, and often no well-defined intermediate goal), the slowness of research, the unanswerable questions, the false starts, the false endings, the bad equipment (scientists in industry may get nice toys, but we're still using a two-pan balance), the low pay (compared to engineering, science does not seem to pay very well), the long hours, the setbacks, and the general misery accompanying any occupation, exciting or numbing—despite all this, scientists persist (and in this I count myself among them). And it is this persistence in the face of what seem to be at best discouraging conditions that has earned the research community its position in our social structure and view of the world.

Science is not so much a priesthood as a craftsmen's guild, and it is this quality that ensures that those who are not part of it are still interested and curious to see for themselves a "real lab."

Science is not so much a priesthood as a craftman's guild, and it is this quality which insures that those who are not part of it are still interested and curious to see for themselves a "real lab."

Obituaries

D. A. Shepard

Stephen M. Paneitz, 1955-1983

Stephen M. Paneitz, Ph.D.'80, assistant professor of mathematics, died on September 1 in a drowning accident in Clausthal, Germany, where he was attending a conference on mathematical physics. He was 28.

Professor Paneitz joined M.I.T. in September 1982, having held a postdoctoral fellowship at the University of California from 1980-82. He was a specialist in quantum field theory; Professor Irving Segal, a collaborator, described Paneitz as "perhaps the most promising I've seen . . . in any graduate school among my students or others." And Professor Daniel J. Kleitman, head of the department, described Paneitz' death was "a serious loss to us and to mathematics."

Robert S. Woodbury, 1907-1983

Robert S. Woodbury, '28, professor emeritus of the history of technology at M.I.T., died on September 18 in Needham, Mass. He was 76, having retired from active teaching in 1972.

Professor Woodbury was the author of several books and articles on the history of machinery, the field in which he had specialized since completing his master's degree in the history of science from Harvard in 1936. He held the Usher Prize (1961) of the Society of the History of Technology, of which he was treasurer for a number of years.

Professor Woodbury's first teaching at M.I.T. was in 1929; he served in the Navy, rising to the rank of commander, during World War II and then continued on the M.I.T. faculty.

David A. Shepard, 1903-1983: 32 Years a Member of the Corporation

David A. Shepard, '26, retired executive vice-president of the Exxon Corp. who had been a member of the M.I.T. Corporation since 1951, died at his home in Greenwich, Conn., on July 10. He was 80.

James R. Killian, Jr., '26, former chairman of the Corporation, wrote of his classmate, "His courtly manner and warm personality endeared him to all of us, and his distinguished career as an engineer, corporate leader, and public servant stirred devotion and respect."

After receiving two degrees from M.I.T. in chemical engineering, Shepard joined Standard Oil Co. (New Jersey)—now Exxon—in research and development, and he remained with that firm throughout his career. He spent a total of 15 years for the company in Europe, serving as a representative to many international petroleum organizations. By 1949 he was executive vice-president and a director.

In the words of David S. Saxon, '41, chairman of the Corporation, Shepard "did virtually everything a Corporation member can do for his alma mater." Even before his election to the Corporation, Shepard was active as president of his class (his tenure in that post extended from 1926 to 1981) and in various Alumni Association activities. Later he served on countless Corporation committees, including many visiting committees, and he was at the same time active in many other public service organizations.

George J. Leness, 1903-1983

George J. Leness, '26, retired chairman of Merrill Lynch, Pierce Fenner and Smith who was life member emeritus of the Corporation, died on August 17; he was 80.

Mr. Leness studied civil engineering at M.I.T. and then continued for an A.B. degree from Harvard before joining the underwriting firm of Harris Forbes and Co., where he became a specialist in utilities financing. Then he moved to First Boston Corp. for nine years, rising to be vice-president, before going to Merrill Lynch as general partner.

First elected to the M.I.T. Corporation in 1949, Leness became a life member in 1961, when he was named to the Executive Committee for a two-year term. Later he served on other Corporation committees and in other important alumni posts. " . . . An alumnus of whom the Institute is exceptionally proud," said David S. Saxon, '41, chairman of the Corporation, "a staunch friend and ally."

Lester Wolfe, 1897-1983

Lester Wolfe, '19, inventor, builder, and patron of the arts and sciences, died at his summer home in Southampton, N.Y., on July 6; he was 86.

Mr. Wolfe was an active supporter of the arts at M.I.T., and in 1979 he established the Lester Wolfe Professorship in Molecular Biology. More recently he had been working with Professor Michael Feld of the Spectroscopy Laboratory on the use of lasers in treating arteriosclerosis; he had established a graduate fellowship in that field. He had also provided funds for prizes to students in materials science, humanities, and the arts.

As president of William J. Roundtree Co., New York, Mr. Wolfe pioneered containerized ocean shipping.

Mark J. Dondero, 1913-1983

Mark J. Dondero, who was the Institute's first safety officer from 1949 until his retirement in 1978, died on June 29 in Arlington, Mass. He was 70.

At the time of his M.I.T. appointment, Dondero was believed to be the first safety engineer at any U.S. college or university, and he was a founder and former chairman of the Campus Safety Association. Dondero studied industrial engineering at Northeastern and served as a safety engineer in several industries before coming to M.I.T.

Elbert P. Little, 1912-1983

Elbert P. Little, executive director of the Physical Sciences Study Committee from 1956 to 1958, died in Falmouth on July 19; he was 71. Before coming to M.I.T. Dr. Little had

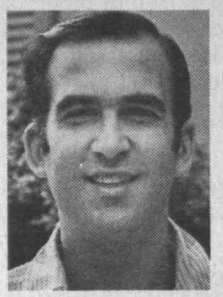
taught physics at Phillips Exeter Academy, and later he was a member of the faculty at Wayne University. His work with PSSC led to a number of books by members of the project and to several films, including "An Introduction to Optics" which is still used as a teaching aid.

Deceased

John Hall, '04; July 13, 1983; 3838 Halifax Rd., Wilmington, N.C.
Maurice H. Pease, '07; September 10, 1983; 5093 Starfish Ave., Naples, Fla.
John S. Barnes, '08; 1980; 18 Woodland Rd., Lawrenceville, N.J.
Mrs. Earl W. Pilling, '10; 1983; 767 Washington St., Norwood, Mass.
Lloyd C. Cooley, '11; October 2, 1982; Plymouth Harbor Apt. 2205, 700 John Ringling Blvd., Sarasota, Fla.
Clarence R. Woodward, '12; February 24, 1983; 905 Country Club Dr., Greensburg, Penn.
Louis C. Rosenberg, '13; June 9, 1983; c/o Mt. View Convalescent Circle, 1400 Division St., Oregon City, Ore.
Raymond A. Meader, '17; February 8, 1980; 16522 Burr Hill, c/o D F Malder, San Antonio, Tex.
James M. Todd, '18; March 23, 1983; 1489 Clairmont Pl., Nashville, Tenn.
Dean K. Webster, Jr., '19; July 29, 1983; 27 Royal Crest Dr., Lawrence, Mass.
Mendum B. Littlefield, '20; July 4, 1983; Littleton House, Littleton, Mass.
Weston Hadden, '21; June 14, 1983; 22 Monument Ave., Bennington, Vt.
Harry M. Ramsay, '21; May 12, 1983; 11 E Orange Grove Rd. No. 116, Tucson, Ariz.
Edwin L. Rose, '21; July 7, 1983; PO Box 116, Sierra Madre, Calif.
Haywood P. Cavlarly, Jr., '22; June 25, 1983; 1615 North Oleander Ave., Datona Beach, Fla.
William J. Edmonds, '22; July 1, 1983; 2701 Gulf Shore Blvd. N., Naples, Fla.
Morris H. Gens, '22; April 29, 1983; 75 Lee St., Brookline, Mass.
Charles T. McGrady, '22; May 15, 1983.
John J. Breen, '23; June 6, 1974; 174 Summit Ave., Summit, N.J.
Mrs. Kenneth G. Crompton, '23; 1983; 407 Prospect St., Lawrence, Mass.
Kenneth C. Kingsley, '23; June 9, 1983; 649 Via Lido Soud, Newport Beach, Calif.
Theodore M. Burkholder, '24; August 4, 1983; 60 Summit St., Newton, Mass.
Charles E. Herrstrom, '24; September 1, 1983; 700 John Ringling Blvd. No. 905, Sarasota, Fla.
Jacob A. Manian, '24; April 10, 1983; 39 Acorn Circle Apt. 202, Towson, Md.
Samuel Glaser, '25; August 7, 1983; 381 Dudley Rd., New Centre, Mass.
Samuel J. Cole, '26; May 10, 1983; 11 Wilde Ave. Apt. 2, Drexel Hill, Penn.
George J. Leness, '26; August 17, 1983; 31 E 79th St., New York, N.Y.
Lucas E. Bannon, '27; March 29, 1983; 19 No. Columbus St., Beverly Hill, Fla.
Francis T. Cahill, '27; June 29, 1983; McKoy Rd., North Eastham, Mass.
Richard Cutts, Jr., '27; March 3, 1983; 305 Greenwich Ave. Apt. 130B, Warwick, R.I.
Frank G. Kear, '27; July 22, 1983; 501 Portola Rd. No. 8085, Menlo Park, Calif.
Mrs. Thorwald Larson, '28; October 2, 1982; 1535 Pine Valley Blvd. No. 110, Ann Arbor, Mich.
Robert S. Woodbury, '28; September 18, 1983; 12 Meadowbrook Rd., Dover, Mass.
Russell B. Wright, '28; October 14, 1982; c/o Mrs. Henry Giugni, 1518 Adams St., Saint Helena, Calif.
J. Gordon Carr, '29; August 10, 1983; 46 Beechcroft Rd., Greenwich, Conn.
Daniel J. O'Connell, '29; July 14, 1983; 50 Elliot St., Holyoke, Mass.
H. Dayton Wilde, '29; July 20, 1983; 3013 Avalon Pl., Houston, Tex.
Denis R. Agar, '30; August 2, 1983; 2625 Regina St. No. 1706, Ottawa, Ont., Canada.
William Harold Bethel, '30; August 28, 1982; Hallmark Nursing Home, 49 Marvin Ave., Troy, N.Y.
Edward H. Clouser, '31; September 1956; 308 Druid Rd., Clearwater, Fla.
Eliot S. Graham, '31; August 1, 1983; 2331A Avenida Sevilla, Laguna Hills, Calif.
Michael Kundrath, '31; August 6, 1983; 144 Red Oak Rd., Fairfield, Conn.
Edwyn A. Eddy, '32; September 11, 1983; RFD 1, Winsted, Conn.
John W. Leslie, '32; June 29, 1983; 42 Whitney St., Medford, Mass.
Dominic A. Perry, '32; July 7, 1983; 533 Paddock Ave., Meriden, Conn.
Joseph L. Richmond, '32; 1972.
Robert M. Trimble, '33; March 1983.
George R. Forsburg, '35; August 7, 1983; 78 Clisby Ave., Dedham, Mass.
John A. Kleinhans, '36; September 13, 1983; 3064 Kent Rd. Apt. 411A, Cuyahoga Falls, Ohio.
Leo F. McKenney, '36; August 19, 1983; Dogford Rd., Etna, N.H.
Morril B. Spaulding, Jr., '36; 1980; 4341 Montgomery Ave., Bethesda, Md.
Harrison S. Woodman, '36; June 28, 1983; 53 Buena Vista Ave., Rumson, N.J.
Willard R. Beye, '38; September 3, 1983; 4414 Marseilles St., San Diego, Calif.
Francis S. Stein, '38; June 17, 1983; 5 Brooke Ave., Annapolis, Md.
Don Cornish, '39; 1981; 17846 Ballinger Way NE, Seattle, Wash.
Akim S. Zaburunov, '39; June 10, 1983; PO Box 1703, Fort Collins, Col.
Oliver K. Smith, '40; August 11, 1983; 1025 Las Pulgas Rd., Pacific Palisades, Calif.
Merlen C. Bullock, '42; September 17, 1983; 2007 North Medina Line Rd., Akron, Ohio.
Louis V. Sutton, Jr., '42; July 15, 1983; PO Box 3085, Rock Hill, S.C.
Robert A. Bamford, '43; July 2, 1983; 20 Rene Rd., Brockton, Mass.
Frank W. Bailey, '46; 1982; 60 Parkway Dr. E., East Orange, N.J.
Stuart D. Grandfield, '46; August 23, 1983; 328 Barranca Ave. No. 2, Santa Barbara, Calif.
William W. Caudill, '47; June 25, 1983; 10923 Kirwick, Houston, Tex.
Boynton H. Tucker, '49; March 1983; RT 25H Box 34A, Malakoff, Tex.
Arthur H. Schein, '51; September 14, 1983; 22 Puritan Rd. Newton Highlands, Mass.
Walter J. K. Tannenberg, '52; July 12, 1983; 1 Longfellow Pl., Boston, Mass.
Barton Roessler, '55; June 16, 1983; 4 Indigo Rd., Barrington, R.I.
Philip T. Andrews, '57; March 25, 1983; 20 Gunderson Rd., Wilmington, Mass.
William H. Coghill, '57; December 24, 1982; 1111 5th Ave., Sebring, Fla.
Miguel A. Barasorda, '59; December 30, 1981; Orquidea 12, Sta Maria, Rio Piedras, Puerto Rico.
Sylvia C. Bluhm, '59; December 16, 1981; 1253 Cambridge Ave., Morgantown, W.V.
Robert R. Thompson, '59; November 1978.
C. Morgan Harris, '62; August 1977.
Robert K. Bofah, '71; 1983; PO Box 10, Goaso, Ghana.
Harry Boothman, '73; 1977; City of Calgary, Parks and Recreation Dept., Calgary, Alt., Canada.
Robert U. Sautter, '74; May 7, 1982; 54736 Merrifield Dr., Mishawaka, Ind.
Christopher Lawlor, '75; August 25, 1982; 9285 Root Rd., North Ridgeville, Ohio.
William G. McCabe, '77; May 16, 1983; 20 Hillside Ave., Haverstraw, N.Y.
Stephen D. Holland, '79; September 11, 1983; Baker Bridge Rd., Lincoln, Mass.
Stephen M. Paneitz, '80; September 1, 1983; 8 Goodman Rd., Cambridge, Mass.
Sudhir K. Sarin, '83; August 7, 1983; 80 Ranleigh Ave., Toronto, Ont., Canada.

Edible Checkers and a Freshman's Folly

Puzzle Corner/Allan J. Gottlieb

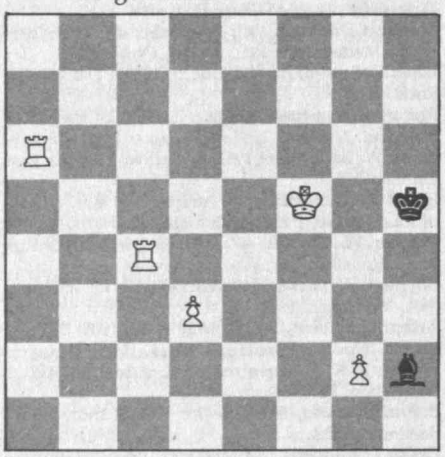


Allan J. Gottlieb, '67, is associate research professor at the Courant Institute of Mathematical Sciences of New York University; he studied mathematics at M.I.T. and Brandeis. Send problems, solutions, and comments to him at the Courant Institute, New York University, 251 Mercer St., New York, N.Y. 10012.

A lovely letter from Mary Lindenberg reports that the M.I.T. and Hunter College alumni associations each met last June 10 at M.I.T.—and she was part of both events. Ms. Lindenberg has an unusual double career; she is a teacher of mathematics and also of painting. She has recently sent us a reprint of her article on originality and creativity—topics germane to both disciplines.

Problems

N/D 1 We begin with a chess problem from George Farnell:



White is to play and mate in three.

N/D 2 Mitchell Serota recalls that cancelling d's to give

$dy/dx = y/x$

is known as "freshman's folly." But similar jokes occasionally work for arithmetic:

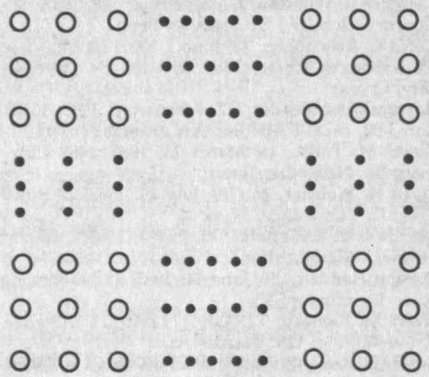
$64/16 = 4/1$

$326/163 = 2/1$

Can anyone find a four-digit counterpart?

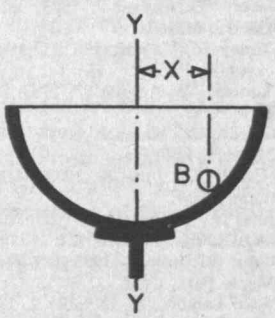
N/D3 Niles Ritter and Andrew Bernoff first sent this problem to M^3, the M.I.T. math majors' magazine (why not call it M^4?):

At the Mathematics Department tea, I had a collection of equal numbers of red and black checkers, and when the conversation grew dull I discovered that my checkers could be arranged in a rectangular array, with all the black ones on the border, like this:



But when my back was turned, one of the professors ate a few of each color, thinking my checkers to be cookies. I found that I still had an equal number of black and red checkers, and that I could still arrange them in an array with the reds inside and the blacks on the border. How many checkers did I start with, and how many were eaten?

N/D 4 This problem, described as "a curiosity from the field of speed indication," first appeared in *Technology Review* in 1938 as part of an advertisment for Calibron Products, Inc."



A hemispherical bowl with a radius of 1 foot 1 inch is mounted on a central vertical shaft YY. A one-pound ball B with a radius of 1 inch is free to roll inside the bowl. On what part of the bowl's surface will the ball tend to ride (i.e., what will be the value of x) if the bowl is spun at 50 R.P.M. about the YY axis? How do

you explain this peculiar result? Show that x will increase to about 7 inches at a speed of 60 R.P.M.

N/D 5 John Rule wants you to find two five-digit perfect squares that together contain all ten digits. How many solutions exist?

Speed Department

N/D SD 1 A bridge quickie from Doug Van Patter:

You (playing East) are defending against a six-heart contract in a high-stakes game:

North (dummy):
♠ 9 6 2
♥ K 4 3
♦ A 8
♣ A 9 7 6 2

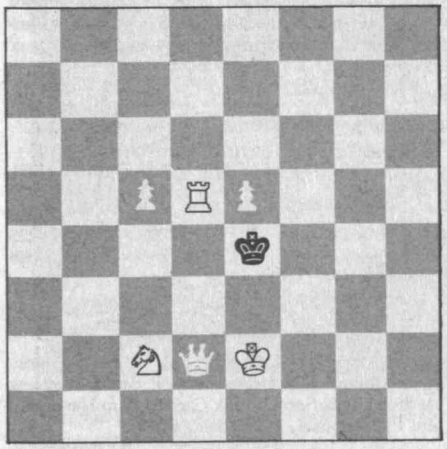
East:
♠ K Q J 8 3
♥ J
♦ K 10 5
♣ K 8 4 3

Your partner leads the ♣5, taken by the ♣A. Declarer pulls three rounds of trump, then leads the ♣Q to your ♣K. Your partner shows out. Can you find a way to save a lot of money?

N/D SD 2 David Evans has drawn a diagonal on each of two faces of a cube so that the diagonals share a vertex. How large is the angle between the diagonals?

Solutions

F/M 1 White to mate in three:



There are several solutions to this problem, which was first published in February/March 1983 and corrected in July 1983. Elliot Robert found the following:

1. R d 6 K x P
2. K f 3 K f S
3. Q f 4

1. K f S
2. K f 3 K x P
3. Q f 4

Also solved by E. Stout, David Evans, Robert Way, Matthew Fountain, Charles Rivers, Randy Kimble, and the proposers, Bob Kimble and Jacques Labelle.

JUL 1 South is to make six spades, with the opening lead from West ♥Q.

	♠ J 9 8 7 2 ♥ 5 4 ♦ A 5 4 ♣ A K 2	
♠ 6 5 4 ♥ Q J 10 9 8 3 2 ♦ 9 ♣ 9 6		♠ — ♥ 7 6 ♦ Q J 10 8 7 6 ♣ Q J 10 8 7
	♠ A K Q 10 3 ♥ A K ♦ K 3 2 ♣ 5 4	

We received a fine analysis from Robert Way:

The experienced bridge player will be disappointed that the spade trumps are divided five-and-five in the declarer's hand and dummy, providing no extra ruffing values. On the other hand, he will note that an "automatic" squeeze is available in clubs and diamonds against East once West has been stripped of these suits and a trick has been conceded to "rectify the count." The latter can be accomplished by losing a trump trick to West after stripping clubs and diamonds. The trick comes back via a "ruff and discard" return and sets up the ultimate "automatic squeeze" against East. In more mundane terms, the simplest play follows. Although the opening lead is specified as the ♥Q, the hand may be made against any opening lead, which declarer wins by following suit with the ♥A, ♠A, ♦K, or ♣A. South must first win these tricks plus the ♠K, ♥K, and ♣K. For these first seven tricks, both the order of play and the cards from the other three hands are not critical, as long as they follow suit. On the eighth lead, South plays the ♠3, following with the ♠2 from North, forcing West to win with a higher spade. West, having been stripped of all other suits, must return a heart which North trumps, and South discards a diamond so as to retain a club as the potential squeeze card. (Note that West, having to return a heart on the ninth trick, has promoted a spade winner in the North hand which otherwise would have fallen under a spade winner in the South hand due to the five-five even distribution, thus regaining the trick lost at trick eight and also delaying the tempo of the game so that East is subsequently squeezed.) North now leads his last spade, which is taken by South's ♠Q; followed by the ♥Q on which North discards a club. The position after 11 tricks have been played: West holds no diamonds or clubs, North holds the ♦A and a small diamond, South holds a small diamond and a small club (!), and East can have only two cards, too. If both are diamonds, South plays his good club and to North's ♦A; if East retains a club, he can hold only one diamond, and after the play of North's ♦A the small diamond is good. Note the problem if the Declarer plays the ♦A (instead of the ♦K) among the first seven tricks: the squeeze position is then transferred to North who must win the last trump trick. This requires Declarer to save the ♠J in the dummy. On the forced heart return at the ninth trick North discards a diamond and South trumps with the ♠Q in order to "unblock" the spade suit. The ♠10 is then led to the North's ♠J and the last spade cashed, discarding a club from South. After 11 tricks, North holds a small diamond and small club, while South retains the ♦K and a small diamond. Likewise, East, reduced to two cards, cannot protect both diamonds and clubs. This line of play is forced if the North-South clubs are interchanged and the East-West clubs are swapped for diamonds. Then declarer must play both the ♦A and ♦K plus a high club to strip West, requiring the final squeeze to be initiated by North.

Also solved by Garabed Zaratarian, Robert Lax, Matthew Fountain, Kenneth Bernstein, Peter De Florez, Conrad Carlson, Doug Van Patter, Tom Harriman, Ben Feinswog, Eric Liban, Charles Rivers, and the proposer, Winslow Hartford.

JUL 2 The number of ways the play of a hand of bridge can proceed obviously depends on the distribution and the choice of trump. Can some reasonably tight upper or lower bounds be found? How about an average case analysis?

Matthew Fountain points out an interesting ambiguity. Consider a hand in which each hand consists of 13 cards of the same suit. For any contract, each player may legally play his 13 cards in any order. Thus we have $13!^4$ possibilities, clearly an upper bound. However, in some sense all these ways of playing the hand are equivalent, so perhaps this deal should be considered an obvious *lower* bound with only *one* possibility. However, since this is a combinatorial and not a bridge problem, we will not try to define equivalent hands. Thus we have an upper bound.

Winslow Hartford has an idea for a lower bound. The lower limit is for a 4-3-3-3 hand, all around, in which one player holds say ♠AKQJ ♥AKQ ♦AKQ ♣AKQ. This will give the fewest choices of play as the winning hand is randomly played out. Thus there are only 432 ways of playing the first trick, as opposed to 28,561 for the case above. This is instictive, but it should be about correct.

Also solved by Robert Way, Tom Harriman, and the proposer, Jerry Grossman.

JUL 3 Two cryptarithmetic puzzles: Nine is a square, and while NINETEEN isn't actually a prime, at least its smallest factor is greater than 150. TWO + TWENTY = TWELVE + TEN. (The first three are all divisible by their namesakes.)

The following solution is from Charles Rivers:

NINE is a square and NINETEEN has no prime factor smaller than 150. Therefore N is clearly an odd number. Of the four-digit squares (32^2 through 99^2), only four have equal first and third digits, and of these, only one ($56^2 = 3136$) has equal first and third *odd* digits. Therefore:

NINE = 3136

NINETEEN = 3136X663, where X = 0,2,4,5,7,8,9

Substitution of each possibility in turn and factoring gives the following results:

X =	0	2	4	5	7	8	9
Smallest factor of NINETEEN =	89	3	11	3	617	3	13

Therefore, NINETEEN = 31367663 with factors of 617, 50839.

The second part of the problem is somewhat more difficult:

1. Since TWO is divisible by 2, O is an even number.
2. Since TWENTY is divisible by 20, Y=0 and T is an even number.
3. Since TWELVE is divisible by 12 (and all its factors including 4), E is an even number with the further restriction that if E=0,4,8, V is even, and if E=2,6, V is odd.
4. O + Y = O, an even number with no carryover. Therefore E + N equals an even number, and since E is even, N is also even.
5. All even numbers are accounted for (Y=0,T,O,E,N) so L,V,W are odd and E=2 or 6 (see 3 above).
6. From 4 above, T+W is odd (no carryover). Therefore E + N must be less than 10 (no carryover) so that E + V + carryover (if any) is odd. Therefore: E + N = O and O = 6 or 8; E = 2 or 6:

Y	O	E	N	T
0	6	2	4	8
0	8	2	6	4
0	8	6	2	4

7. From all this, TW + NT = LV + TE and L = N + 1.
8. Rearranging and solving for W - V:

10T + W + 10N + T = 10L + V + 10T + E

W - V = 10(L-N) + E - T

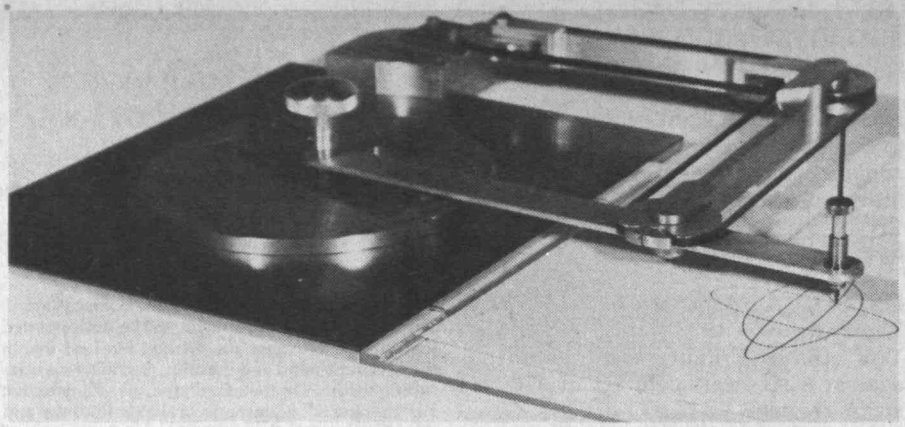
9. Therefore

Y	O	E	N	T	L	W-V	W	V	TWELVE	
0	6	2	4	8	5	4	7	3	872532	− 12 = 72711
0	8	2	6	4	7	8	9	1	492712	− 12 = 41059.333
0	8	6	2	4	1	−8	1	9	W ≠ L	

10. The solution is:

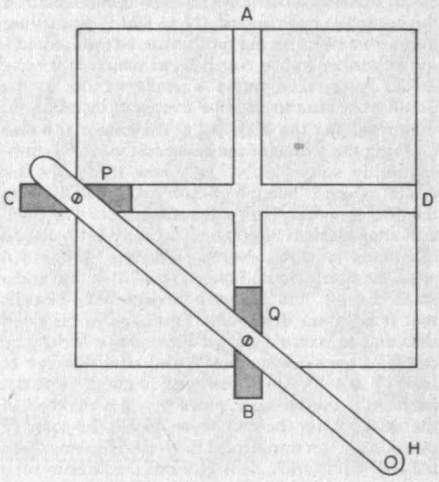
876	872532
872480	824
873356	= 873356

Also solved by Matthew Fountain, David Evans, Kenneth Bernstein, Fred Furland, Carlyn Iuzzolino, Winslow Hartford, Robert Way, Sidney Feldman, John Spalding, W. Woods, Harry Zaremba, Frank Davis, John Rule, and the proposer, Avi Ornstein.

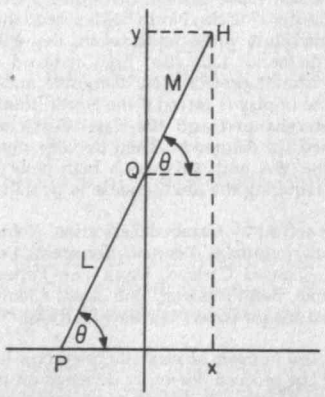


When Anthony Stanton asked "Puzzle Corner" readers (JUL 4) about the geometry of a slotted block with travelers in the slots, Martin Buerger, emeritus professor of mineralogy and crystallography at M.I.T., realized that Stanton's device was essentially equivalent to this machine—Buerger's invention—for drawing ellipses. Buerger's description of the machine is available on request from the editors.

JUL 4 A block of wood has slots AB and CD, as shown. In each slot is a wood piece, P and Q, that can slide in it. Also shown is a bar attached by loose screws to P and Q and extended to a handle H. Is it possible to rotate the handle through a full 360° without having P and Q collide? If this is possible, is the orbit of H an elipse?



The blocks cannot collide since they must remain a distance PQ apart. Kelly Woods shows us that the orbit of H is indeed an ellipse:



Let the distance PQ be designated by L and the distance QH by M. Then, as shown in the diagram,

$y = (M + L) \sin \theta$
$x = M \cos \theta$
The equation of an ellipse is:
$(x/a)^2 + (y/b)^2 = 1$
In this case the minor semi-axis is a = M and the major semi-axis is b = (M + L), from which:
$\cos^2 \theta + \sin^2 \theta = 1$.

Martin Buerger, professor emeritus at M.I.T., constructed such a device in the 1940s, a photograph of which appears above. Professor Buerger has supplied a written description of the machine, which can be obtained from the editor upon request. And Norman Wickstrand notes that Keuffel and Esser once sold such an instrument.

Also solved by Kenneth Bernstein, Matthew Fountain, Tom Harriman, Fred Furland, Eric Liban, Winslow Hartford, Waller Moore, Gary Heiligman, John Prussing, Phelps Meaker, Harry Zaremba, Frank Davis, and Robert Way.

JUL 5 The following list is the first 19 perfect squares containing two distinct digits and not containing a zero. What are the next two elements of the sequence:

4 × 4 = 16	22 × 22 = 484
5 × 5 = 25	26 × 26 = 676
6 × 6 = 36	38 × 38 = 1444
7 × 7 = 49	88 × 88 = 7744
8 × 8 = 64	109 × 109 = 11881
9 × 9 = 81	173 × 173 = 29929
11 × 11 = 121	212 × 212 = 44944
12 × 12 = 144	235 × 235 = 55225
15 × 15 = 225	264 × 264 = 69696
21 × 21 = 441	

Carlyn Iuzzolino found:
$3114^2 = 9{,}696{,}996$
$81619^2 = 6{,}661{,}661{,}161$

Also solved by Matthew Fountain, David Evans, Kenneth Bernstein, Robert Way, E. Stout, Winslow Hartford, Italo Servi, Frank Carbin, Tom Harriman, and the proposer, Nob Yoshigahara.

Better Late Than Never

M/J2 Garabed Zartarian has responded.
M/J5 Arvi Ornstein has responded.

Proposers' Solutions to Speed Problems

N/D SD1 Put the ♦K on the table. This may lose a diamond trick, but it guarantees that the Declarer won't be able to pitch losers on Dummy's last two clubs. (Declarer's ♣J is still blocking the suit.)

N/D SD2 60°. A third diagonal can be drawn forming an equilateral triangle.

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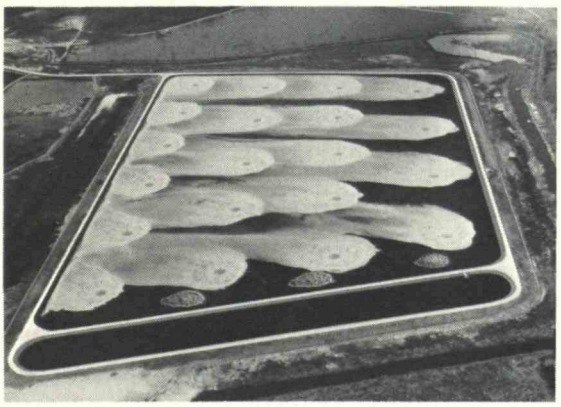

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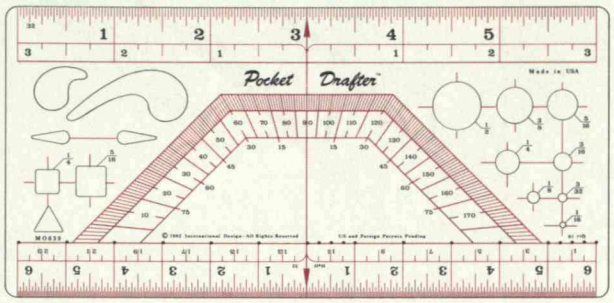

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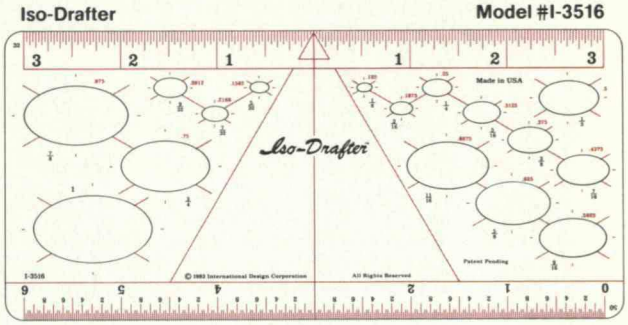

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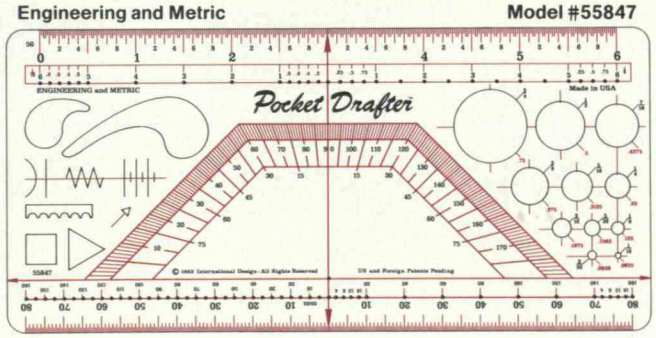

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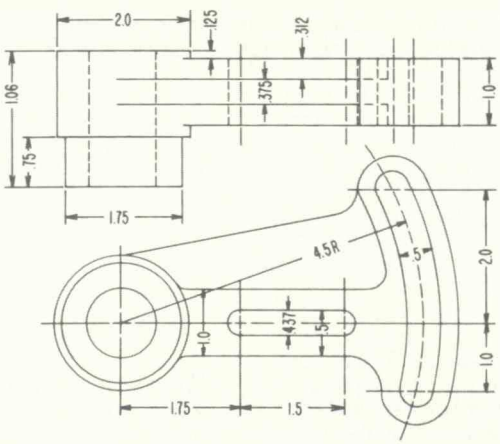

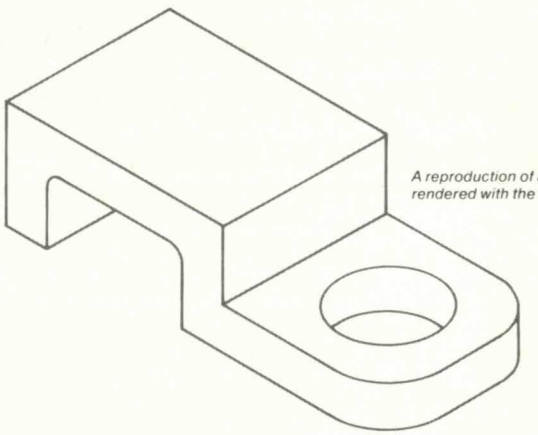

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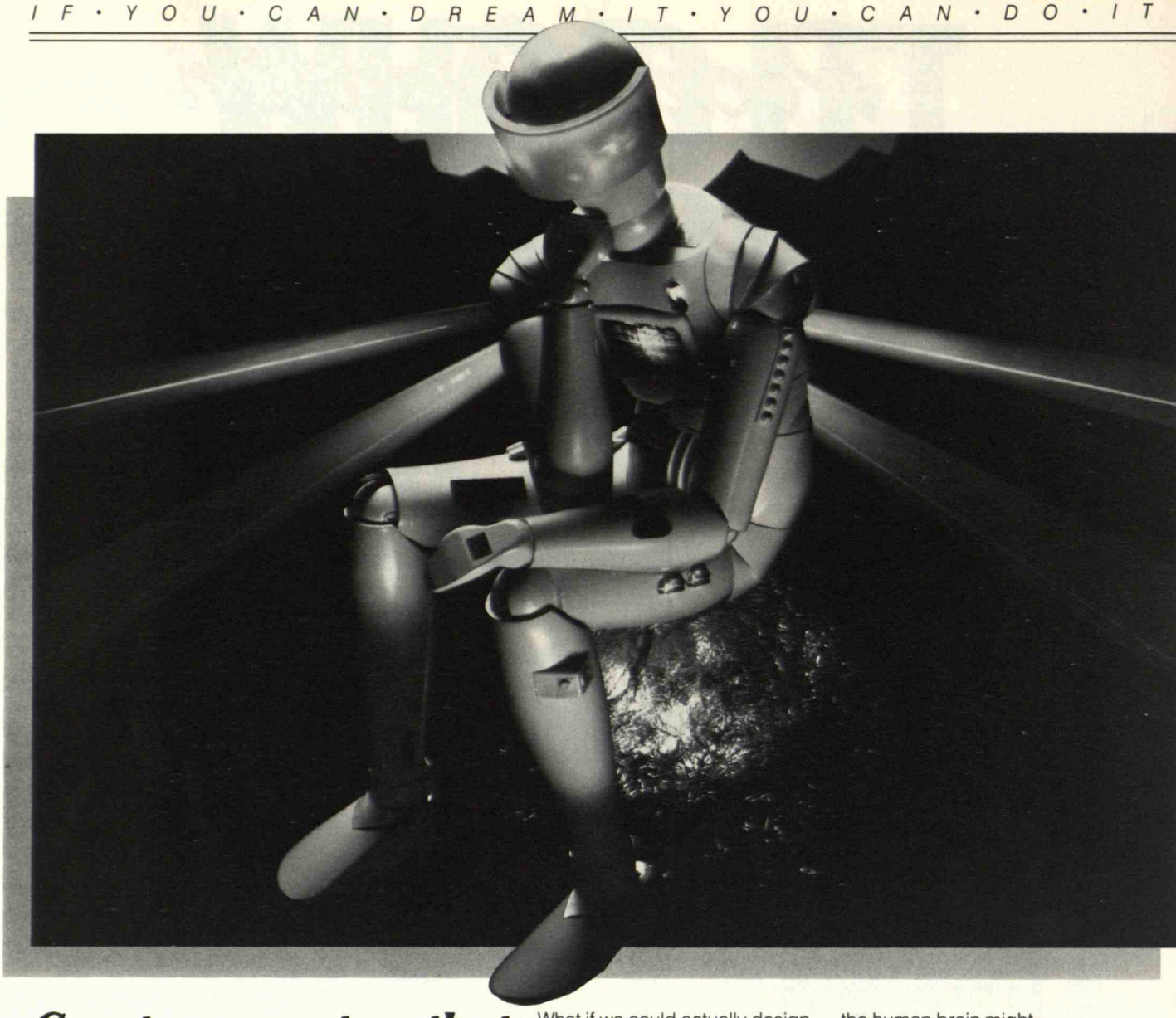

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We are also looking at parallel processing, a method that divides problems into parts and attacks them simultaneously, rather than sequentially, the way the human brain might.

While extending technology and application of computer systems is important, the real excitement and the challenge of knowledge engineering is its conception. At the heart of all expert systems are master engineers and technicians, preserving their knowledge and experience, questioning their logic and dissecting their dreams. As one young employee said, "At GE, we're not just shaping machines and technology. We're shaping opportunity."

Thinking about the possibilities is the first step to making things happen. And it all starts with an eagerness to dream, a willingness to dare and the determination to make visions, reality.

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Urokinase, an enzyme used to treat heart attacks, must be laboriously produced from urine and costs $3000 per treatment. Production of the enzyme by genetically engineered bacteria promises tremendous savings.

about 1 million people in the United States. The enzyme is traditionally produced from human urine, in which it is present in a low concentration. This makes it very expensive—the urokinase required to treat one patient today costs about $3,000. Recently, the gene for the enzyme was inserted in bacteria. The enzyme that the bacteria produce is identical to the human enzyme and therefore is not rejected by the immune system. This process promises to greatly reduce the cost of treatment.

In these two instances, genetic engineering is making a natural enzyme easier to produce, and the same method can be extended to other enzymes. In the long term, genetic engineering will also be used to alter nature's enzymes to more closely satisfy the biotechnologist's needs. Enzymes will be made more stable and active, and their catalytic properties will be specially tailored. Consider the example of converting a mixture of L- and D-amino acids to pure L-amino acids by using aminoacylase. This enzyme works very well with certain amino acids—such as methionine, valine, and phenylalanine—and not so well with others. Genetic engineering should make it possible to change the primary structure of aminoacylase so that it will be able to convert any amino acid.

Unnatural Properties

Another significant recent trend in enzyme technology is the use of "unnatural" properties of enzymes. Although enzymes are usually very specific as to the reactions they catalyze, many can also catalyze chemical reactions different from their normal reactions if conditions are changed. Although such unnatural properties of enzymes are unimportant for the enzyme-producing organism, they can be very valuable for biotechnology.

For instance, the enzyme peroxidase normally catalyzes various small molecules in plants and trees to combine into long polymers to form lignin, the woody structure of the cell walls. This reaction may also be commercially useful. My laboratory has recently developed a process based on the enzyme peroxidase for removing hazardous organic pollutants from industrial wastewaters. But by using peroxidase in a different sort of aqueous solution, our laboratory has been able to produce L-dopa, an important drug for treating patients with Parkinson's disease, and adrenaline, used to treat patients with heart disease.

Not only can enzymes catalyze such unnatural reactions, they can also be forced to function in unusual environments. For instance, one of the chief difficulties of using enzymes as catalysts in organic chemistry is that many compounds of interest to the chemical industry are not soluble in water, while enzymes work only in water. This problem can be solved if the reaction takes place in two phases. The enzyme is dissolved in an aqueous solution, while the substrates—the chemicals to be acted upon—are dissolved in an organic solvent. The aqueous solution is mixed in the solvent, rather like water mixed in gasoline. The substrates diffuse from the solvent into the aqueous solution and are acted upon by the enzyme; then the products diffuse back into the organic solvent. Since the amount of water in such systems can be very small, they strongly resemble pure organic solvents, yet the enzymes are not adversely affected. Our laboratory has used this approach to enzymatically produce compounds useful in synthesizing drugs and agricultural chemicals. These chemicals could not have been produced in conventional aqueous solutions.

A dramatic reduction in the concentration of water can also reverse some reactions catalyzed by enzymes. For example, in water the enzyme lipase breaks down lipids (oils similar to butter or margarine). In nearly water-free systems, however, the enzyme catalyzes the opposite reaction, synthesizing lipids from their components, fatty acids and glycerol. This unnatural reaction of lipase has been used by Unilever Co. to produce some oils used in foods.

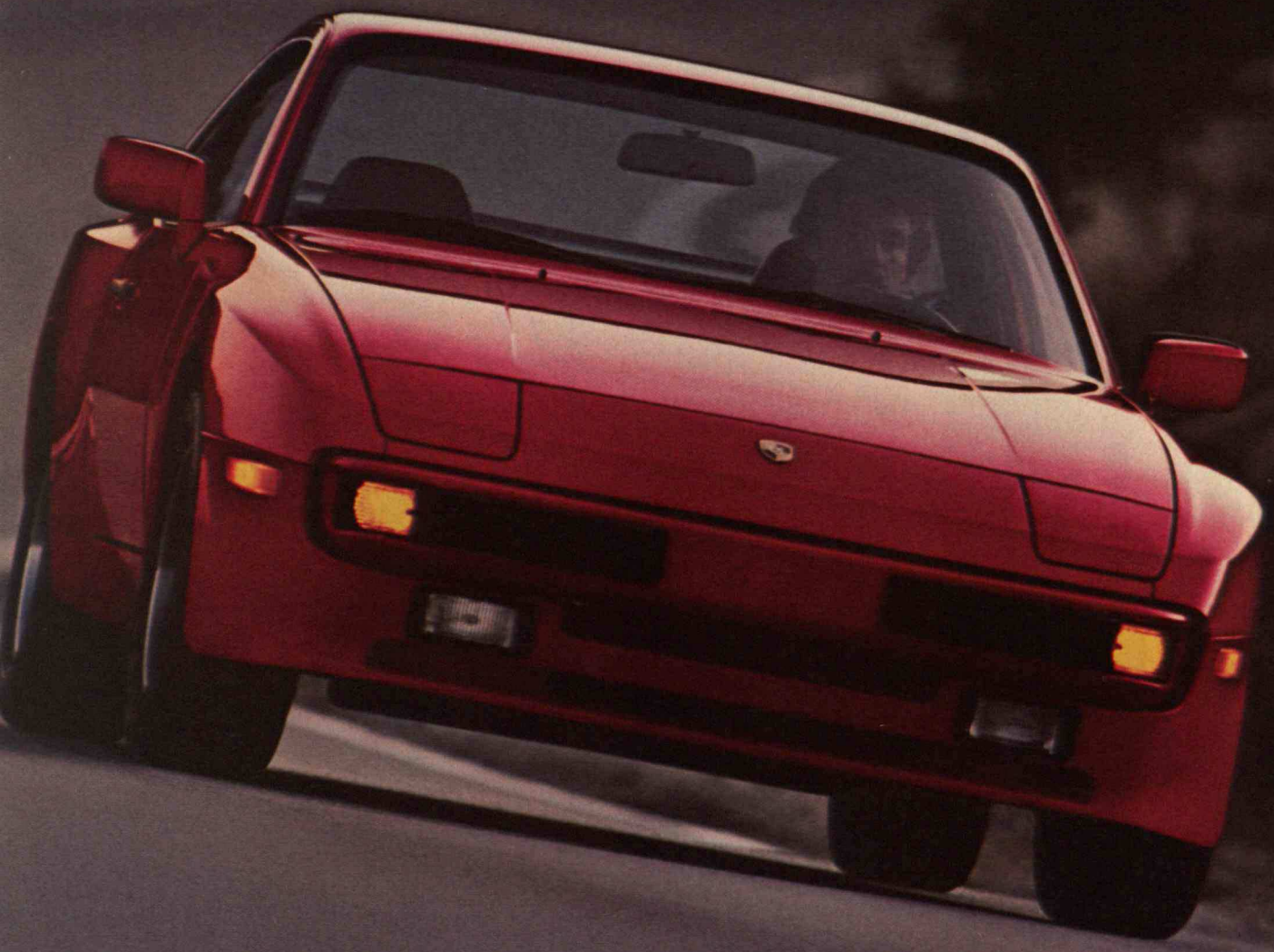
These are key features of the past, present, and possible future of enzyme technology. Its potential is great, but so is the complexity of the technical problems to be solved. In immobilization, we have a lot to learn about how to make enzymes more stable. In genetic engineering, we know the properties of enzymes we would like to obtain, and we know how to alter the primary structure of enzymes. But we do not know what changes in the primary structure will bring about given changes in the enzyme's behavior. Tremendous efforts over the next 10 to 20 years will be required to illuminate these matters, yet the trouble is surely worth our while. Success promises better human health, more plentiful supplies of food and energy, and a cleaner environment.

ALEXANDER M. KLIBANOV is associate professor of applied biochemistry at M.I.T.

Consumer Orientation
No. 24 in a series
Subject: Design objective: maximum performance, not maximum production.

24 Porsche 944

Engineered for maximum performance, the design of the Porsche 944 does not lend itself to ease and speed of assembly. We cannot increase our production schedule because to do so would mean to compromise the outstanding quality and performance that created the exceptional demand for this automobile in the first place.

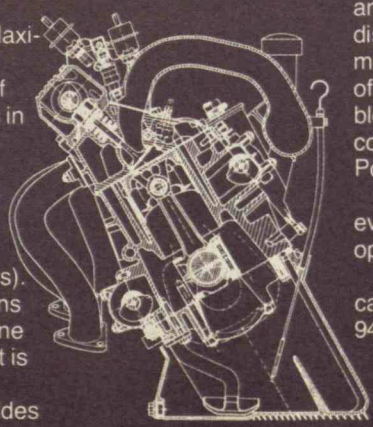


The Porsche 944 accelerates from 0 to 50 mph in 5.9 seconds. Top speed is 130 mph. Maximum torque is achieved as low as 3000 rpm.

Behind these impressive numbers is one of the largest, most powerful 4-cylinder engines in production: 2.5 liters, 143 hp.

To counter the vibrations an engine of this magnitude would normally produce, Porsche engineers have incorporated a system of counter-rotating silencer shafts and special engine mounts (actually mini shock absorbers).

The result: a 4-cylinder power plant that runs with the smoothness of a 6. Building the engine is, by necessity, a slow process, but the result is a high performance automobile.



Porsche's exclusive transaxle design provides an almost perfectly balanced front/rear weight distribution. This design requires drive train elements to be constructed as a single unit, instead of as individual components. Difficult to assemble, it contributes to the exceptional handling, cornering and directional control unique to Porsche.

From its internal mechanics to its ergonomics, every aspect of the Porsche 944 is designed to optimize performance.

To insure high performace and quality, every car is inspected, every engine is tested, and every 944 is run on the open road prior to shipment.

The Porsche 944 is the antithesis of the mass produced automobile. But then, at Porsche, excellence is expected.

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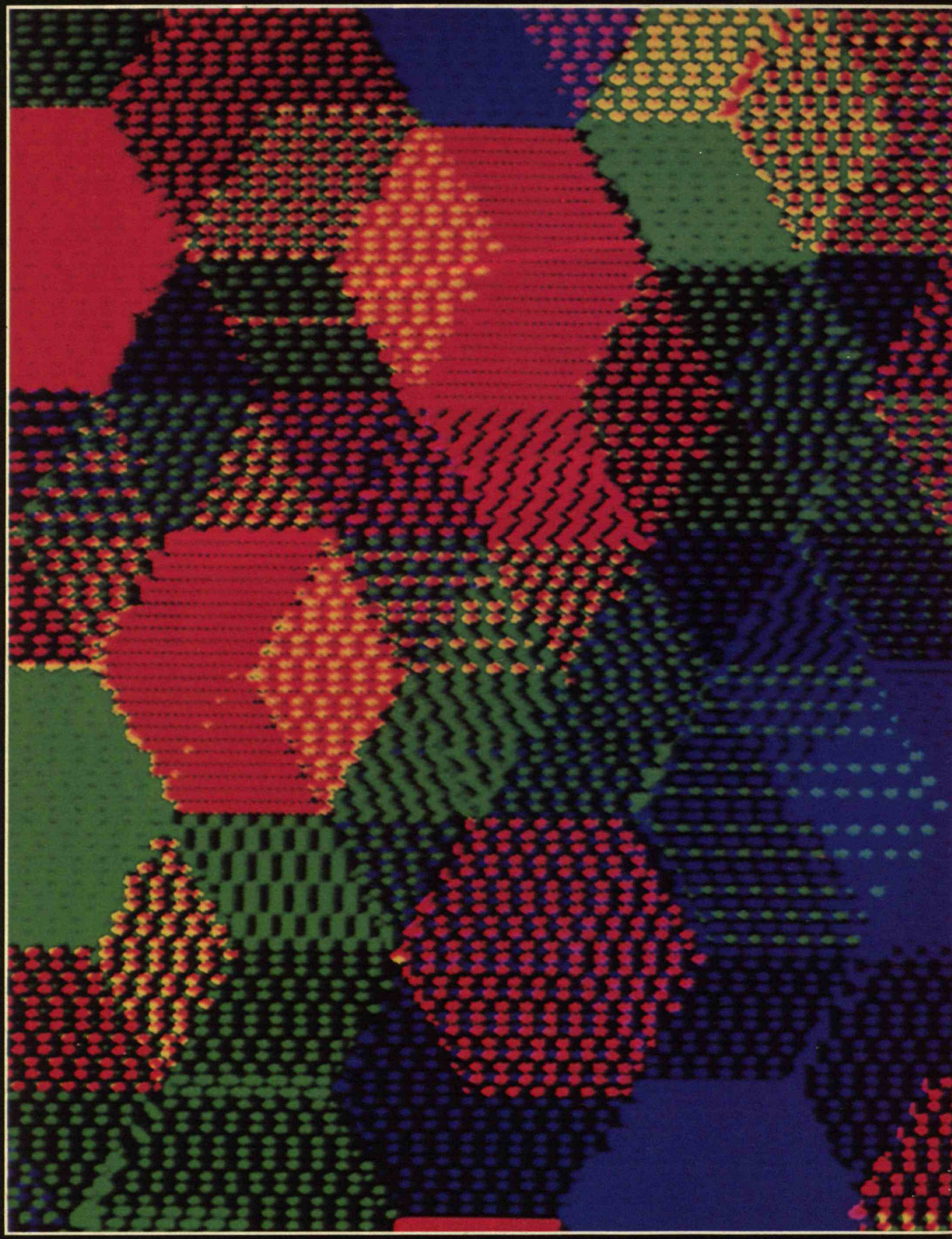
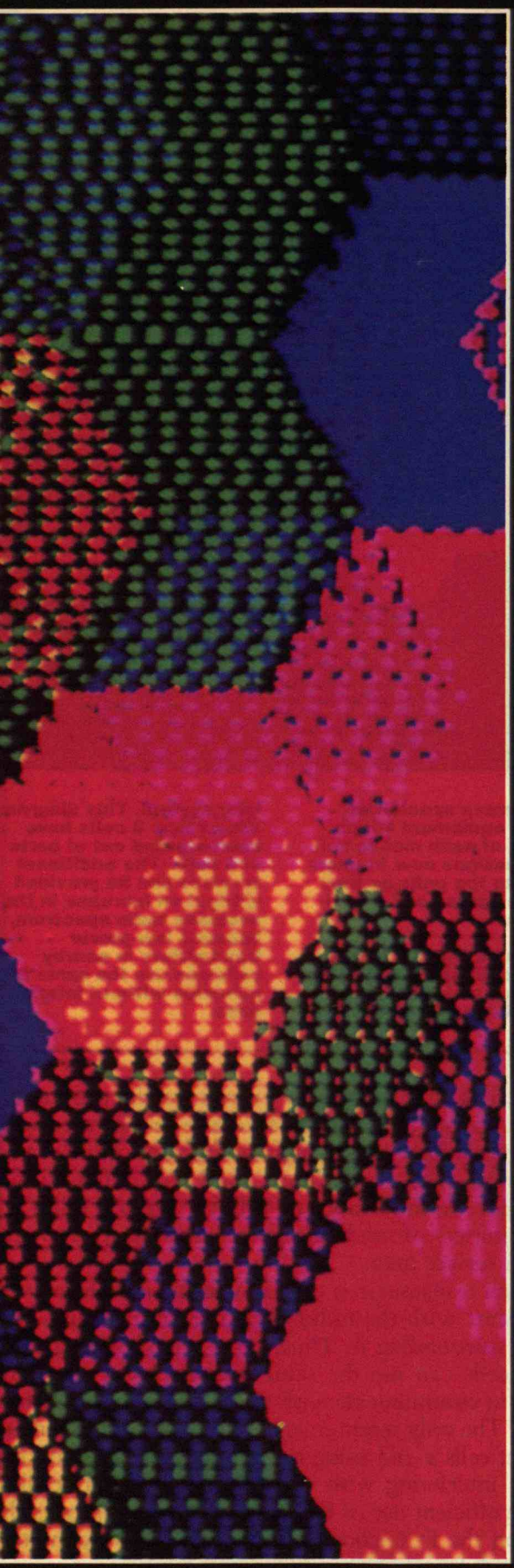
NOTHING EVEN COMES CLOSE





Cellular Radio

BY DUANE L. HUFF

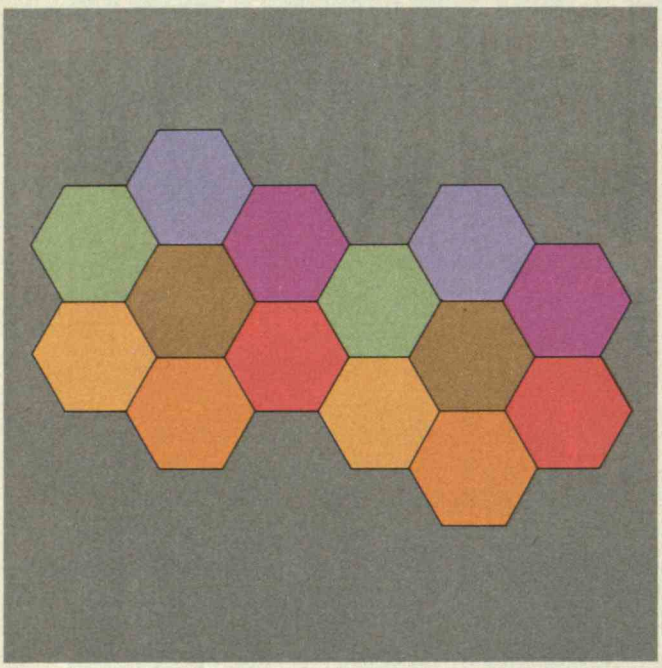
Telephoning on the move: how the new technology works and how we'll use it.

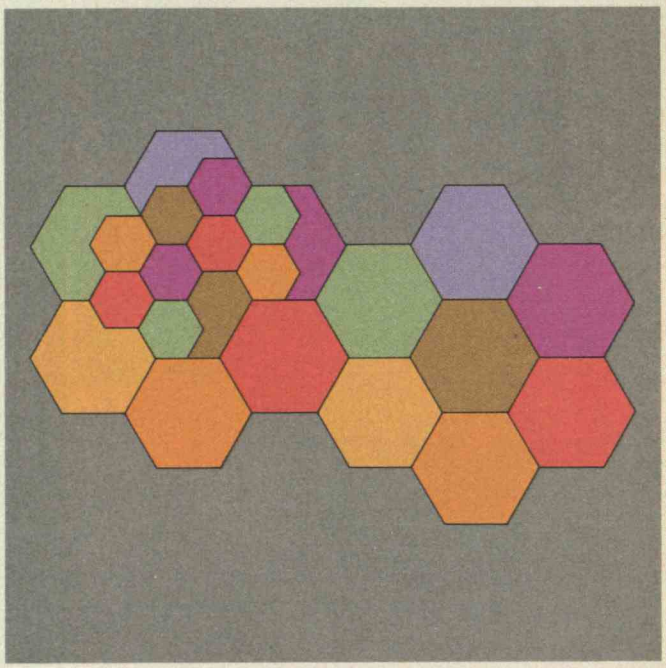
Most of us regard a telephone on the dashboard or a "walkie-talkie" radio in the hand as a luxury or a status symbol rather than a necessity. But a new technology called cellular radio is now emerging to make high-quality, full-service mobile telephones and radio transceivers much more widely available. Mobile communications that have been for 20 years a curiosity will become commonplace—and soon enough a necessity for many.

Most market studies suggest that cellular-radio technology will increase the number of mobile telephone users tenfold within the first few years. Projections for the use of hand-held, portable radiotelephones based on cellular technology are equally optimistic. The result is likely to be one of the greatest changes in communications patterns since the invention of the telephone.

After years of effort to select the most efficient way to meet increasing demand for high-quality mobile communications, the Federal Communications Commission (FCC) has accepted the cellular-radio concept. Early this year the agency began taking applications to operate such systems in the 90 largest U.S. markets, and it will shortly accept applications to serve other markets as well. No technical, legal, or regulatory uncertainties remain. Many other industrialized countries have already installed or are actively planning cellular-radio systems. Third World countries are also planning to use this technology in the absence of conventional wire or optical transmission facilities.

ILLUSTRATION: TOM NORTON





The advantage of cellular radio for mobile telephone systems is "frequency reuse": a limited spectrum of radio frequencies can be made to serve many users. The area to be served is divided into cells—in this case 14. A low-power radio transmitter—powerful enough to reach any mobile unit in the cell but not powerful enough to interfere with transmissions in distant cells—is located in each cell. Thus, the frequencies assigned to the transmitter in the farthest-right cells in this diagram can be used again without interference by transmitters in the center of the diagram. A central microprocessor teamed with more specialized radio equipment keeps track of each mobile unit and assigns new frequencies to the units as they move across cell boundaries.

Cell splitting is a simple way to keep up with growing demand for mobile telephone services in a cellular system. This diagram shows how 9 cells have been created out of parts of 4 cells. The additional services can be provided without an increase in the available radio spectrum, because low-power transmitters in nearby cells can use the same frequencies without interference.

Searching for the Choicest Cell

Less than one-tenth of 1 percent of the 150 million vehicles now in use in the United States have mobile telephones. This is because until now, mobile communications have been limited by a lack of radio channels: each mobile telephone has required exclusive use of one channel in the available spectrum of frequencies. Cellular systems conquer this limitation by using low-power transmitters of limited range, so that each channel can be used simultaneously in many different geographic "cells." Taken together, these cells make up the total service area of a system.

This idea of frequency reuse is familiar. Hundreds of television stations across the country that are out of one another's ranges, and therefore cannot interfere with one another, reuse television channels 2 through 13 in the VHF band. Cellular telephone systems reuse frequencies on a much smaller geographic scale. Instead of covering an entire service area with one transmitter with high power and an elevated antenna—the technology used for conventional mobile communications—cellular service relies on transmitters of moderate power distributed throughout a service area.

Each transmitter is only powerful enough to communicate with the radiotelephones in its "cell"—the area surrounding it. Thus, other transmitters in distant cells can use the same frequencies at the same time to communicate with mobile telephones in their cells. The only requirement is that transmitters in adjacent cells avoid using the same frequencies to keep from interfering with one another. Cellular radio's more efficient use of the frequency spectrum was the reason the FCC chose it as the standard technology for mobile public communications.

Though simple in concept, the cellular system is complex in execution. Computerized control systems are the key to its efficient operation.

Consider how a mobile telephone in a cellular system operates. As a vehicle in which a telephone call is in progress on a particular channel moves from one cell to another, the call is automatically transferred to the neighboring cell. There the call is conducted on different frequencies, to which both mobile and fixed transmitters and receivers are automatically assigned. This transfer should take place without the users' awareness; there is no break or perceptible difference in the communication. This function—the transfer of a conversation from one cell to another—is usually called "handoff."

Although the system is simple in concept, it is complex in execution, demanding specialized computers and intricate sensors and controls. For example, one popular way to perform the handoff function is to monitor the quality of the signal for each telephone call received at a cell site. When the signal quality starts to degrade, nearby cells are automatically requested to measure the quality of the signal to determine which cell could better serve the call. When a better candidate is chosen, an idle radio channel at the new cell is selected, and a digital message on the "old" radio channel instructs the mobile equipment to tune to the new channel in the "new" cell. Control techniques have now been developed so that conversations continue without interruption. (If no new channel is available, the handoff procedure can be briefly delayed, or the call can be transferred to an adjacent cell where transmission is adequate though not optimal.)

When a customer's mobile equipment is turned on but not in use, it periodically scans special control channels broadcasting at each cell site in the system, selecting the strongest signal to monitor for incoming calls. When an incoming call is detected, or when the user wants to make a call, the user's equipment rescans the cells to be sure it is still working with the strongest signal (usually the nearest cell).

Calls to a mobile terminal are initiated just like normal telephone calls. A seven-digit number (ten digits if the mobile party is in a different area code) is dialed, and the conventional telephone network routes the call to the central computer of the mobile party's cellular system. From here the number is sent to all cell sites in the system, and each transmits the number of the called terminal on its control channel. When the called mobile terminal detects the incoming call, it selects the best cell with which to establish the communication and sends its identification back to the system through this cell. The system then uses a digital message to designate a frequency for the mobile terminal to use, the receiver tunes to this frequency, and the user is alerted to the incoming call by ringing.

A similar sequence is involved when a mobile user originates a call. The user first dials the desired number at a register in the mobile unit. The unit then chooses the best cell site and transmits the called number over the control channel. The main computer designates the frequency to be used to complete the call, and the mobile unit is automatically tuned to this frequency.

All the control information between the terminal equipment and the system is redundantly coded and repeated to prevent errors. The entire exchange of control information takes place in a fraction of a second, and none is heard by the user. To the user, the sending and receiving of calls is routine—standard telephone procedure.

Cellular radio systems actually use two separate frequencies for each transmitter-receiver pair. This allows "full-duplex" service, which means that both parties in a conversation can talk at once. This contrasts with one-way systems such as citizens'-band, ship-to-shore, and private radio. In these, the same frequency is used for transmission and reception, so transmission requires pressing a "push-to-talk" button that disables the receiver.

The computer control systems are the key to efficient operation of cellular-radio communication. Computers at the mobile telephone switching office (MTSO) activate computers at the cell sites and, through these, the computers in the mobile units. Both cell sites and mobile units possess a degree of autonomy and a considerable amount of intelligence. In many cellular systems, the computer in the cell site performs most of the handoff functions, including measuring signal quality and comparing results with other cell sites. It also performs diagnostic tests and reports trouble in any equipment at the cell site. The microprocessors at these sites must cooperate with the processors of the MTSO to form an efficient system. The microprocessors in mobile units have important error-detection functions, in addition to controlling some terminal hardware and keeping mobile units tuned to the strongest cell sites.

Special features for cellular systems are limited only by the ingenuity of the developers. These currently include options such as one- or two-digit speed cal-

Interconnections called "roaming" will provide customers with mobile telephone service even on long-distance automobile trips.

ling; call-forwarding, message-waiting, and three-way calling; locking devices to prevent unauthorized use; data transmission; and automatic callback. In short, mobile telephones based on cellular technology offer essentially all the services available on conventional telephones.

The same cellular concept can be applied to serve portable radiotelephones with built-in power supplies. Many market studies suggest that these radio links may be the most important early uses of the cellular concept. A briefcase-size radio weighing 10 to 20 pounds that can be used for a number of days without battery recharge is now available. Construction supervisors, for example, use such units to maintain contact with their own and subcontractors' offices while on the job. At the other end of the spectrum is a hand-held, lightweight radiotelephone unit that pedestrians—doctors, for example—can use where conventional telephones are not available. This unit requires new batteries (or recharge) after a few hours of use. We may not yet have achieved Dick Tracy's wristwatch-sized communications unit, but we are clearly making a close approach!

How Radios Roam and Cells Divide

A service called "roaming" allows customers with mobile radio service in one cellular system to use their units in another system as they travel. Roaming works this way: When mobile equipment is taken into a new cellular system, the roaming feature identifies the equipment to the new system, which then informs the home system of the user's whereabouts. Calls coming into the home system for the user are rerouted to the correct "foreign" system. The roaming function includes computerized systems that exchange billing and payment information and permit operators to identify fraudulent users, illegal equipment, and bad credit risks. When cellular systems are fully developed, roaming—essentially complete mobile long-distance service—will be possible, with no special actions required by the user.

Though developers expect strong demand for cellular mobile services, startup facilities can be small, with orderly growth possible as mobile traffic increases. When the traffic in one cell becomes greater than that cell can handle, the cell can be divided into smaller cells. Transmission power is reduced to avoid radio interference among the new cells, each of which serves about as many customers as the original cell.

Most startup systems use cells with radii of 8 to 12 miles. These systems can be split three times if necessary, with the minimum radius being 1 to 1.5 miles. New cells can be created to meet demands for service outside the original area. In most systems, the maximum number of customers per cell, without excessive service delays, is 3,000.

The Demand to Talk on the Move

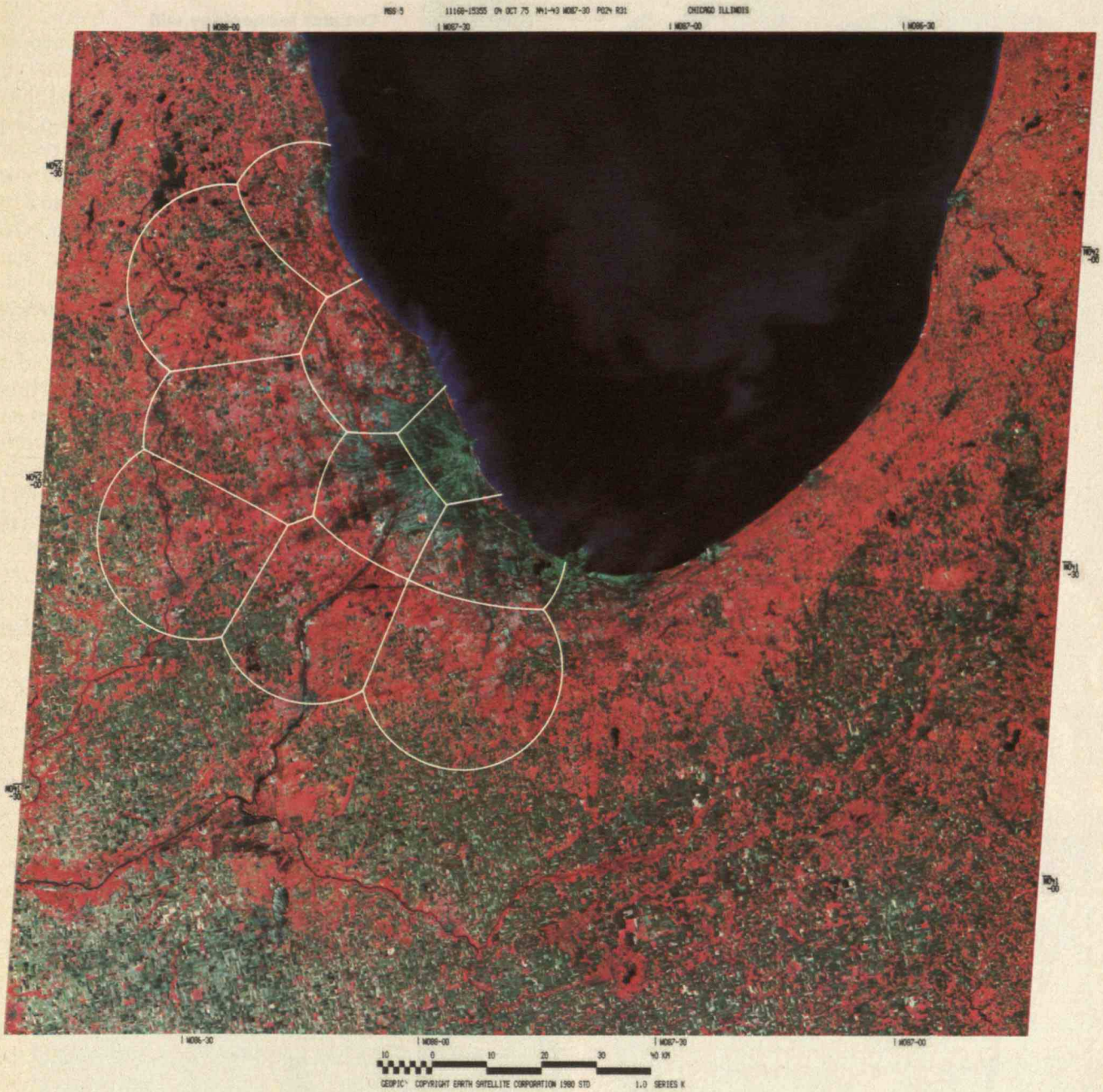
The potential market for mobile communications was recognized soon after the invention of radio. The first major use of this potential came quickly, as radio was employed to communicate with moving vessels at sea for navigation and safety. Today the use of mobile radio has spread dramatically to include land vehicles—public-safety and service vehicles and taxis, to name but three—as well as aircraft and ships. Indeed, some 8 million mobile units are licensed for private radio service in the United States today. Over 8 million "citizens'-band" radio units are also in use in this country.

At the end of World War II, the demand for public mobile telephone service induced the Bell System to test-market the service in St. Louis. Six frequencies were chosen, but the equipment was not sophisticated enough to prevent interference from adjacent channels. Thus, just three frequencies were actually used, so only a few customers could be served. One year later the Bell System tested a public mobile system along the highway between New York and Boston. This system also proved troublesome because of erratic radio propagation: short-range radio was blanked out in some areas, while interfering conversations were carried for long distances.

Despite these difficulties, Bell gradually extended mobile telephone service to other markets, and by the late 1940s there were long waiting lists in several metropolitan areas. Indeed, over 25,000 people are on waiting lists for mobile telephones today, with many more would-be users not even bothering to add their names. The number of channels assigned to a typical mobile telephone system are so few that subscribers frequently cannot make or receive calls when they wish, so new customers obviously cannot be accommodated.

Bell Laboratories planners were already looking forward to a more economical and efficient form of mobile telephone service when the first systems were being installed in the 1940s. The basic cellular con-

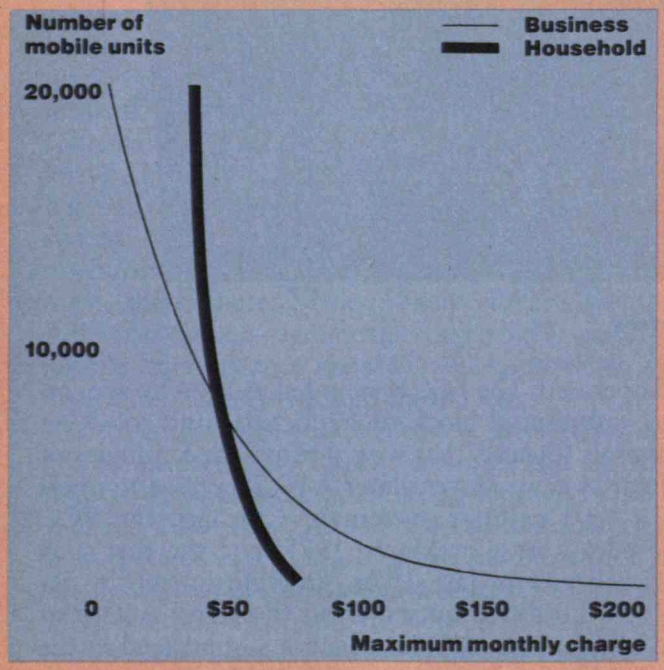
This system in Chicago, authorized as a trial in 1977, provided the first cellular mobile telecommunications in the U.S. The 10 cells covered an area of about 2,100 square miles and provided 136 voice channels—making possible 136 simultaneous telephone conversations—serving 2,000 customers. Bell Labs engineers estimated that only 2 percent of these customers would receive busy signals during peak demand. A fully developed cellular system will provide this level of service to more than 100,000 mobile units. The cellular diagram is superimposed on an Earth Satellite Corp. photo © 1975.

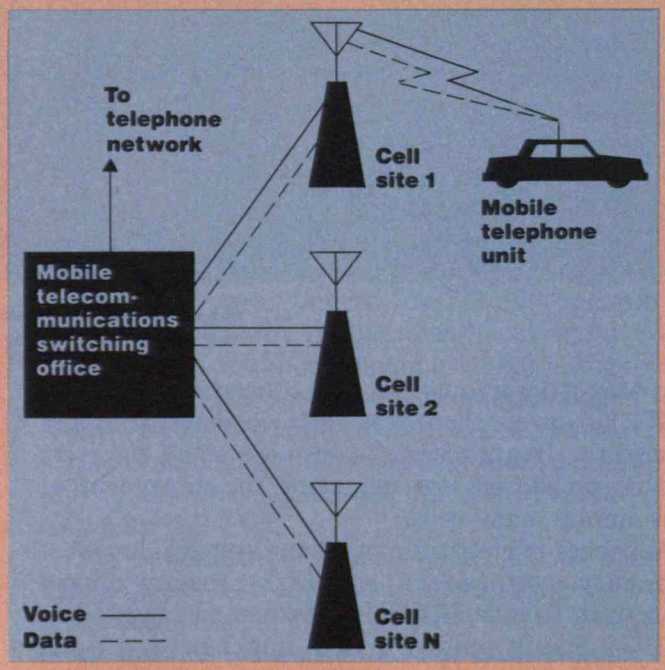


cept of reusing frequencies was conceived as early as 1947. However, there was then no way to rapidly change the frequencies of transmitters and receivers and no techniques for managing the movement of calls among many cells.

Advances in electronic switching systems, low-cost frequency synthesizers, and high-capacity microprocessors stimulated the Bell System to suggest late in 1971 how a cellular system might be developed and operated. The FCC responded in 1974 by allocating a substantial block of frequencies and soliciting proposals for tests that would prove the feasibility of cellular systems. A year later AT&T applied to operate a trial cellular system in Chicago, the FCC granted a license in March 1977, and the first such service began in late 1978, growing quickly to its limit of 2,000 customers. Soon thereafter American Radio Telephone Service began a similar trial in the

Cellular technology will add mobility and dependability to telephones in vehicles (left) and to hand-held radio transceivers (right). Cell sites such as those in the photograph have computers to manage frequency selection and switching, with data channels as well as communications channels to mobile customers and to central switching offices.





Washington-Baltimore area using a system developed by Motorola. Both projects have shown that the basic cellular concept is feasible and can win strong customer support. A third trial, by Millicom, Inc., was authorized in May 1981 and should be operating in the Raleigh-Durham, N.C., area in 1984.

The Chicago system provided the first market test of this new technology. There were 136 voice channels spread across 10 cells, making possible "full-duplex" service—with few busy signals—to a 2,100-square-mile metropolitan area. Potential customers, randomly selected from lists of businesses in the Chicago area, were reached by direct mail, telephone, and personal visits. One out of eight companies contacted subscribed to the service, and most requested more than one mobile unit. Construction companies were especially receptive to mobile telephone service. Least receptive were food retailers, whose customers generally come to them.

Almost all customers cited time saved and convenience as major benefits of cellular radio; many said that productivity increased 20 to 30 percent. An executive of a fast-food chain predicted his company could save 1 million gallons of gasoline a year if all service vehicles were equipped with cellular radios. A trucking company attributed a 30 percent increase in business and a 4,000-gallon fuel saving to cellular service. A real-estate executive claimed a 50 percent increase in productivity, and a representative of a waste-disposal company reduced his automobile mileage by 20 percent. Many executives said they extended their working days by using their telephones while commuting or traveling.

The Beginning of the Cellular Age

With testing complete, widespread use of cellular technology is beginning in the United States. In June 1982, conventional telephone and radio communications companies filed 196 applications to operate cellular systems in the top 30 markets. Two competitors, one a telephone company and the other a radio communications company, will be licensed to serve each area. Competing carriers for each of two licenses in each market are agreeing to a number of joint ventures, but many disputes must still be resolved. The FCC has granted a Bell subsidary, Advanced Mobile Phone Service (AMPS), permission to construct the first 22 commercial cellular systems; the first of these has just begun service in the Chicago

Will Mobile Telephones Move?

BY ITHIEL DE SOLA POOL

GREY-HAIRED readers will recall the flying heroes of their childhood comic books talking across the reaches of space on wristwatch radiotelephones. Now one small step on the road to the fantasy of omnipotent communication is becoming reality with the advent of cellular mobile telephone systems.

This long history of yearning is, however, not yet ended. We must realize that what we see in the next 10 or 15 years, though significant, may change a great deal.

First of all, we must disabuse ourselves of the notion that people want to talk all the time. The average person spends only a quarter of an hour a day talking on the telephone outside of the office. Of course, phone junkies use the telephone much more, and we can expect that they will install cellular phones in their cars as soon as possible and thereafter will feel lonely unless they are talking as they drive along. But many others will hate the very idea of this invasion of the precious solitude of the automobile.

The same uncertainty applies to travelers. We will not know until current market tests are completed how many business travelers will take advantage of the new plane-to-ground telephones. Nor will we know how many passengers will be less comfortable because they are no longer able to sit back in their airline seats, and feel cut off from the tension-loaded world they just left, with nothing to do but drink, eat, sleep, or read.

The Hard Facts of Economics

But the desire for personal conversation is not the main test of the prospective significance of mobile telephones. Their role in increasing business productivity is likely to be far more important than their role in casual conversations.

About 16 million mobile units already serve the roughly 200 million American adults. Where are all of these? (Only 0.1 percent of our vehicles have two-way radios.) They are in the taxis we call, in the police cars and fire engines that serve us, in the repair trucks that come when needed, in the ships and planes that transport us and our goods. There is now an enormous backlog of demand for additional two-way mobile channels in our major metropolitan areas.

But is that perhaps an illusion? In 1977 the Federal Communications Commission (FCC) had made a study of the demand for radio telephony in Chicago. Participants in the study, Robert Crandall and Robert Taggert of M.I.T.'s Research Program on Communications Policy, quickly recognized that there were many ways that distributed services such as taxis and delivery trucks could keep in touch. The choice of mobile radio was based on economics—the government was giving these frequencies away free. Once one's vehicles had a transceiver, mobile communication was a gift. Crandall and Taggart suggested that even with a fairly modest charge for frequency use, congestion might disappear. Now cellular-radio services will have a genuine market test. In contrast to previous mobile radios, cellular service will be billed to customers on a services-rendered basis through a telephone company or other common carrier.

There is good reason to ex-

Continued on page 60

An executive of a fast-food chain predicted his company could save 1 million gallons of gasoline a year with cellular radio.

area. The FCC has also awarded permits to other telephone carriers, as well as to a number of companies set up expressly to provide cellular radio. Meanwhile, nearly 400 applications to provide service in the 30 next-largest markets were filed in November 1982, and 567 applications to serve the sixtieth through ninetieth markets were filed in a third round.

Consumer rates for the new telephone service and for leasing the mobile equipment are being established by the marketplace. Prices will vary widely around the country, depending on individual companies' plans for recovering their large investments. However, the prices tested in Chicago in 1978-79 may typify what many companies will start off with. Basic service (a telephone number and connection to the system) with 120 minutes of free usage cost $25 a month, with "overtime" usage charged at $.25 per minute. Lease of the mobile terminal cost either $45 or $60 per month, depending on the type of set. Thus, the minimum bill was either $70 or $85 per month. Most customers used much more than the 120 minutes of free time, so that the average bill was double the minimum—over $150.

Most experts predict that minimum costs for cellular service will run about $150 per month during the first few years of operation. As the number of users increases, the cost of mobile equipment and services will decrease. If the FCC allocates more frequencies to cellular radio, construction of new cell sites can be delayed, decreasing costs further.

The FCC has reserved a spectrum of 40 megahertz for cellular radio and will assign 20 megahertz to each of two competing companies in a market. Each system will use 30 kilohertz of its assigned frequency for each path between cell and mobile unit—enough to prevent interference and allow all accessories to be used effectively. Thus, 333 channels can be operated

Will Mobile Telephones Move?
Continued from page 59

pect that there will be demand for the service. The old semifree congested service was not of very high quality. With the new cellular service, there will be no more "push-to-talk" and no serious interference. The new systems will bring their users the ability to call anywhere in the country and to add on, at a charge, many of the enhanced services that telecommunications companies will be promoting.

Two-Way Trucking

Those who have studied the possible uses of mobile telephones agree that truck operators—seeking to increase efficiency—will be a major market. When a garbage truck without two-way radio goes out, its managers can only guess at when it will be filled; with mobile telephone service, a second truck could be sent to the right point on the line. So, too, with delivery trucks: computer control and timely communication could vastly improve their efficiency. Traffic congestion could be markedly eased by communications that would tell drivers where there is clogging and how to select alternative routes. A form of jitney service called "dial-a-bus" that is halfway between taxis and mass transportation, based on routing optimized by computer, has long been discussed. Emergency services of all kinds could be improved.

There will be many other potential beneficiaries, too. In the accompanying article, Duane Huff tells us that in the AT&T Chicago experiment, building contractors signed up for the new service quickly but food vendors tended to be laggards. Although that may be a good short-run indication of demand, the long-term outlook should be different. The handling of perishable foods may well be improved by effective mobile communication. The food industry is today organized to minimize dependence on real-time communication. Early in the morning, food is delivered from warehouses to the refrigerators of supermarkets, there to wait for the capricious decisions of the day's (and the next day's) customers. The wastage and loss of flavor are enormous. There could be a system in which customers, as of old, are delivered the perishables that they now pick up themselves. With the day's demand recorded on computers, the various halfway storage systems could be eliminated.

One of the remarkable features of cellular-radio systems is their propensity for graceful growth: cells can be split as traffic grows. Unlike other modern communications systems such as direct satellite broadcasting and videodiscs, cellular radio does not require a massive up-front investment into a system whose capacity must exceed demand for many years before it begins to repay its installation costs.

Making Systems Compatible

Cellular-radio systems are not inherently monopolistic, and they are being set up to encourage competition. But to reach their full potential, communications systems have to be universally interconnectable, and that is not a trivial requirement. How will messages go easily from one system through connecting, competing systems to a system of yet another vendor? Can those services be rendered efficiently and economically? Even such mundane issues as cooperative billing systems may turn out to be costly and complex. □

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in each band of 20 megahertz assigned by the FCC. AMPS estimates that it may develop up to 100 cells in Chicago by 1986 to meet demand. Each cell might have an average of 30 radio channels, for a total of 3,000 channels (which can support 3,000 simultaneous conversations). The total number of customers in that market might approach 75,000 by 1986.

Cellular systems are also being developed overseas. The Nordic Mobile Telephone System, which began operating in 1981 in the four Scandinavian countries, had over 40,000 subscribers in the fall of 1983. The system was originally designed to accommodate only 96,000 subscribers, and expansion to a capacity of 200,000 is now being planned.

A cellular system designed by Nippon Telephone and Telegraph, in operation in Tokyo for a number of years, has recently been extended to Osaka and Kyoto. The system currently serves more than 10,000 subscribers, with over 100,000 projected by 1987. Smaller systems are in use in Mexico, Qatar, United Arab Emirates, Australia, Canada, Austria, and Singapore. Nippon Electric Co. equipment is used in Mexico, Singapore, and Australia; Matsushita equipment is used in Qatar and the United Arab Emirates; and Motorola equipment is used in Austria.

Meanwhile, even while cellular radio is being commercialized, the technology on which it is based is by no means standing still. Improvements such as digitized transmission will reduce the amount of the radio spectrum required for a single call, thus increasing the number of calls that can be processed in a cell. Mobile telephone equipment will shrink in size, and data terminals and printers will be available. Public telephones will be installed in trains, buses, and taxis; indeed, trials of public telephones in commercial airliners are already underway. Cellular telephone services will soon be coupled with answering and message services, encryption and scrambling for privacy, dictation services, data transmission, alarm calls, automatic callback, and all the other auxiliaries now available on conventional telephones.

Cellular services will be available in all major U.S. markets within three to five years. Thus, this technology will form the basis of a competitive marketplace, with unlimited opportunity to provide truly personal telecommunications to users on the move.

After 23 years as a staff member at Bell Laboratories, DUANE L. HUFF early this year became vice-president for technical services of Advanced Mobile Phone Service, Inc., the Bell System subsidiary for cellular development.

Cellular Radio: Why the Cells May Grow Slowly

BY DON GOODING

Cellular radio is so new that no amount of market analysis can accurately predict the demand even five years from now. Nonetheless numerous market projections are made with boundless enthusiasm.

While we predict an eventual multibillion-dollar market for cellular-radio equipment and services, we remain suspicious of any forecast that projects an annual market of $1.5 billion by 1990 and $17 billion by the year 2000.

Nearly every application to the Federal Communications Commission (FCC) for a cellular franchise has included a market projection. Many of these were the result of sophisticated survey techniques in which very specific questions were asked, with the results modified to allow for the propensity of consumers to overstate their willingness to buy.

In general, these market projections for cellular mobile communications look like this:

☐ The total number of nonbusiness subscribers within the first five years may be 1 to 1.5 percent of the total population in an area. By the year 2000, that figure may have risen to 5 percent—but may also be no higher than 2 percent. The major impact will be on upscale consumers: the penetration will be anywhere from 3 to 9 percent in households with incomes over $25,000 a year. Cellular will become a status symbol on Beverly Hills and Park Avenue, but most customers—who will already be seeing hefty increases in monthly local telephone bills—will not be willing to shell out $150 a month for mobile phone service on top of a fairly substantial up-front investment for the equipment (built-in cellular equipment is a $3,000-option in the 1984 Buick Riviera).

☐ The number of business subscribers will be 10 to 15 percent of the number of businesses in any area, and each of these will probably order two or three units. This is consistent with the AT&T market study in Chicago, the only one based on the actual behavior of consumers in a demonstration program. According to this study, 11 percent of the businesses in all the groups surveyed could be expected to subscribe to Bell's Advanced Mobile Phone Service (AMPS) given its present rate structure.

Portable radiotelephones—battery-operated transceivers that can be carried easily and used anywhere—will appeal to more customers than car-mounted mobile telephone units. Portables will allow their users 24-hour access to communications; the average mobile phone user today spends only 40 percent of the day in a car, and most of us spend much less time than that.

The most optimistic members of the nascent industry—notably Millicon, Inc.—believe cellular radio could eventually displace conventional telephone service in providing everyday voice communication to residential and/or large business customers. Millicon has completed market testing of its cellular systems in

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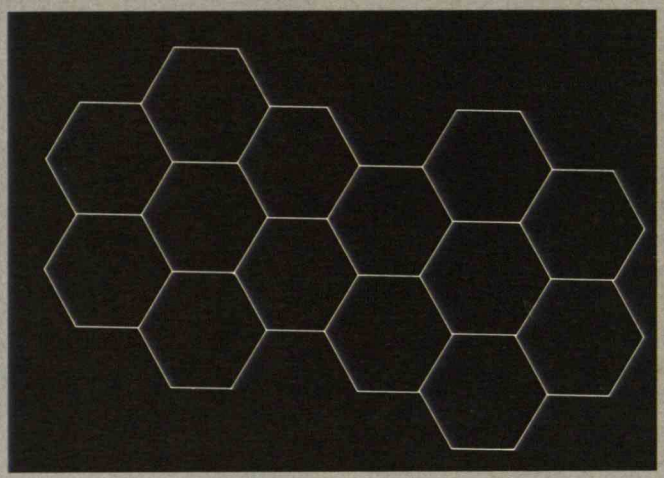
Cellular Radio: Why the Cells May Grow Slowly

Continued from page 61



Raleigh-Durham, N.C., and has applied to provide mobile telephone service in all the markets rated between 61st and 90th in size by the FCC, as well as to export its cellular system to underdeveloped countries. Millicon expects its system to be competitive with conventional telephone primarily in the rural, small urban, and suburban markets. The argument is that escalating local phone rates could force telephone users to resort to cellular systems as a cheaper alternative.

This argument is flawed on two counts. The first is the assumption that rural rates will soar because the subsidy from long-distance telphone service will end. There is powerful political support for moderate rural telephone rates, and it seems unlikely that conventional rates will be allowed to rise to levels at which cellular systems could provide effective competition. For example, the FCC has explicitly required a short-term subsidy that will stabilize rural rates at least temporarily. The second flaw in Millicon's argument is the company's tendency to underestimate costs. We believe that cellular systems for rural customers will be expensive because they will require substantial data-processing capacity. Our conclusion is that rural users are likely to prefer conventional service, at least for the next decade.

Studies on the effect of price on the demand for cellular mobile radio agree that if the cost of cellular radio can be reduced to less than $50 a month, there will be a significant increase in demand. But we do not foresee such drastic cost reductions before the end of the century. The retail cost of the portable phone itself will not be below about $1,000 for at least five years and won't be down to $500 for at least ten years. We believe the total monthly bill for the average user, including equipment lease, monthly service charge, air time, and interconnection to the wireline network, will remain above $100 through 1990. By the time prices fall below that level, the average consumer will have made a considerable investment in new plug-in instruments for conventional telephones and will be reluctant to make a change.

Capricious, Competitive Markets

Makers of cellular equipment—the complex microprocessors and transmitters required at the switching offices—will find a lively market between now and 1985, when 43 new cellular systems will be under development and the pioneering systems of 1983 and 1984 will be expanding rapidly. Then, after some retrenchment, the market will start climbing again in 1987 as large systems begin to add cells to increase capacity. Throughout this period, the market for cellular systems will be highly price-competitive—a struggle between relatively few equipment suppliers.

The market for the mobile and portable equipment used by cellular subscribers will be even more competitive. Already more than a dozen vendors are investing tens of millions of dollars to develop third- and fourth-generation units. While these vendors will try to keep the wholesale price above $2,000 to recover their investments, our research suggests there is a 50-50 chance of a "kamikaze" price-cutter entering the market with $1,000 to $1,500 units within three years. In addition to seeing price competition, this market will be extremely competitive in terms of styling and user features. Since cellular will be sold as a productivity-enhancing service, any features that supposedly increase productivity (such as last-number callback, number memory, and automatic dialing) will be well accepted. We forecast cumulative sales of $3.81 billion through 1990.

Though this initial market will be for mobile units, it will evolve quickly to emphasize hybrid mobile/portables—units that can be comfortably used in a car, attached to the cigarette lighter for power, but that can be removed and used for several hours as portable radio transceivers.

Finally, we believe cellular systems will enter most markets less quickly than most promoters indicate. Delays will arise principally in the regulatory area, since there are many applicants to provide cellular service in the different markets. For example, 1,000 applications are expected for the 61st to 90th markets, and delays will increase in proportion to the number of applicants vying for a particular franchise. There will also be delays because of shortages of trained labor, shortages of cellular hardware, and difficulties in actually implementing the technology. We estimate that the average cellular system in one of the 30-largest markets will take nearly three years to complete. For some cities in the 61st to 90th market, the time elapsed from application to commercial service may be as long as eight years if everything goes wrong. □

DON GOODING is a market analyst for the Yankee Group, communications system consultants, in Boston. He is a Yale economics graduate who specializes in the economics of data transmission. This article is condensed from a Yankee Group report.

The new '84 Ford Tempo. Technology never felt so comfortable.

The inside story.

Tempo's interior is a computer-refined compartment for five. Computer-designed placement of seats, door, roof and window areas afford maximum space efficiency.

Even Tempo's front-wheel-drive configuration was designed to provide more interior room. Since there is no drive shaft, there is no large hump to rob valuable floor space. In fact, Tempo actually has more rear room than a Mercedes 300D.*

For driver's convenience, controls are all placed within easy reach. For added ease, wipers and washer, directionals, high-beams and flash-to-pass are located on the steering column itself.

Technology that works for you.

Outside, a unique aerodynamic shape channels the wind over and around Tempo to help increase fuel efficiency. It also directs the airflow, reducing overall lift for improved stability and directional control.

Its front-wheel drive delivers all-weather traction, while its four-wheel independent suspension provides a smooth ride.

Plus, Tempo has the world's most advanced automotive computer, the EEC-IV. It processes up to 250,000 commands per second. Coupled with Tempo's 2300 HSC (High Swirl Combustion) engine, you get quick power response from a standing start and at cruising speed.

Best-built American cars.

When we say "Quality is Job 1," we are talking about more than a commitment. We are talking about results. An independent survey concluded Ford makes the best-built American cars. The survey measured owner-reported problems during the first three months of ownership of 1983 cars designed and built in the U.S. And that commitment continues in 1984.

*Based on EPA Interior Volume Index.

Have you driven a Ford... lately?

Ford

Just as the theory of evolution changed our view of life, so artificial intelligence will change our view of the mind.

Why People Think Computers Can't

BY MARVIN MINSKY

MOST people think computers cannot think. That is, *really* think. Not now or ever. Everyone knows that computers do many things that no person could do without "thinking." But when you get right down to it, most people are convinced that this is just a mimic of the real thing—that machines won't ever understand anything but commands.

When computers first appeared, their designers regarded them as machines for doing huge, mindless numerical computations. That's why the things were called "comput-ers." Yet even then some people envisioned what's now called "artificial intelligence," or AI. They saw that computers might possibly go beyond arithmetic and imitate the processes that go on inside human minds.

Today, surrounded by so many automatic tellers, industrial robots, and the R2-D2's of *Star Wars* movies, most people think AI has gone much further than it has. Yet many "computer experts" still say machines will never really think. I think those specialists are too used to explaining that there's nothing inside computers but little electric currents. This leads them to believe that there can't be room left for anything else—like minds, or selves. And there are many other reasons why some experts maintain that machines can never be creative, intuitive, or emotional, and will never really think, believe, or understand anything. This essay explains why they are wrong.

ILLUSTRATION: GEOFFREY MOSS

First-rank "creativity" could be just the consequence of little childhood accidents.

Can Computers Be Creative?

We naturally admire our Einsteins and Beethovens and wonder if computers ever could create such wondrous theories or symphonies. Most people think that creativity requires some special "gift" that simply cannot be explained. If so, no computer could create, since, clearly, anything machines can do can be explained.

But we must avoid the trap of looking only at works our culture views as very great. Until we first have some good ideas of how ordinary people do ordinary things, we simply can't expect to guess, right off, how great composers write great symphonies! We shouldn't be so intimidated by our Beethovens and Einsteins. Instead, we ought to be annoyed by our ignorance of how we get our own ideas. The trouble is, when focusing on creativity, we take our own ideas for granted and don't ask where we "get" them from. We're simply so accustomed to the marvels of everyday thought that we never wonder about it.

Do outstanding minds differ from ordinary minds in any special way? I'll argue that there's nothing special in a genius except a rare combination of ingredients, none of which is very special by itself. A genius must have an intense concern with some subject, but that's common enough. There also must be great proficiency in that subject, but this, too, is not so rare; we call it craftsmanship. There has to be enough self-confidence to stand against the scorn of peers. But all these traits seem based on common sense, and not on any fundamental difference. As I see it, anyone who can understand a conversation already possesses most of the mental power our greatest thinkers have. In other words, "ordinary common sense" already includes the things it takes—when better balanced and more fiercely motivated—to make a genius.

Then what makes those first-raters so much better at their work? Perhaps there are two kinds of differences-in-degree from ordinary minds. One is the way such people learn to *manage* what they learn: beneath the surface of their mastery, creative people must have unconscious administrative skills that knit the many things they know together. The other difference concerns why some people learn so many more and better skills. A good composer masters many skills of phrase and theme, but so does anyone who talks coherently. Why do some people learn so much so well? The simplest hypothesis is that they've come across better ways to learn. Perhaps such "gifts" are little more than tricks of higher-order expertise. Just as one child learns to rearrange its building blocks in clever ways, another child might learn to play, inside its head, at rearranging how it learns.

Our culture doesn't encourage us to think much about the process of learning. Instead, we regard it as something that just happens to us. But learning must itself consist of sets of skills we grow ourselves: we start with only some of them and slowly grow the rest. Why don't more people keep on learning more and better learning skills? Because it's not rewarded right away; the payoff has a long delay. When children play with pails and sand, they're usually concerned with goals like learning how to fill pails with sand. But once a child becomes concerned, instead, with how better to learn—figuring out the right way faster—that concern could lead to exponential learning growth. Each better way of learning to learn would lead to better skills—until that little difference had magnified itself into an awesome, qualitative change. Thus, first-rank "creativity" could be just the consequence of little childhood accidents.

So why is genius so rare if each person has almost all it takes? Perhaps because human evolution works with mindless disrespect for individuals. I'm sure no culture in which everyone finds different ways to think could survive. But wouldn't it be sad if evolution required that the genes for genius be weeded out frequently instead of nurtured?

What Is Common Sense?

We can hardly expect to make machines do wonders before we find out how to make them do ordinary, sensible things. The earliest computer programs were little more than simple lists and loops of commands such as "Do this. Do that. Do this and that and this again until that happens." Most people still write programs in languages (such as BASIC or FORTRAN) that force you to imagine everything your program will do from one moment to the next. Let's call this "do now" programming.

Before long, AI researchers found new ways to make programs. In their General Problem Solver system, built in the late 1950s, Allen Newell, J.C. Shaw, and Herbert A. Simon showed ways to describe processes in terms of statements such as "If you're on the wrong side of the door, go through it." Or, more

The networks in our human minds are probably more complex than any other structure science ever contemplated.

technically, "If the difference between what you have and what you want is of kind D, then try to change that difference by using method M." This and other ideas led to what we call "means-ends" and "do-if-needed" programming methods. Such programs automatically apply rules whenever they're needed, so the programmers don't have to anticipate when that will happen. This started an era of programs that could solve problems in ways their programmers could not anticipate, because the programs could be told what sorts of things to try without knowing in advance which would work.

Everyone knows that if you try enough different things at random, eventually you can do anything. But when that takes a million billion trillion years, like those monkeys hitting random typewriter keys, that's not intelligence, that's just chance. The new programs didn't do things randomly but used "advice" about what was likely to work on each kind of problem. So instead of wandering around, such programs could sort of feel around, the way you'd climb a hill in the dark by always moving up the slope. The only trouble was their tendency to get stuck on a little peak and never make it to the real summit of the mountain.

Since then, much AI research has been aimed at finding more "global" methods, to get past different ways of getting stuck by making programs take larger views and plan ahead. Still, no one has discovered a "completely general" way to always find the best method—and no one expects to. Instead, many AI researchers today aim toward programs that will match patterns in memory to decide what to do next. I like to think of this as "do something sensible" programming. A few researchers—too few, I think—experiment with programs that can learn and reason by analogy. These programs will someday recognize which old experiences in memory are most analogous to new situations—that is, they will "remember" which methods worked best on similar problems in the past.

Can Computers Understand?

Can we make computers understand what we tell them? Is "understand" even an idea we can ask science to deal with? In 1965, Daniel Bobrow wrote a program to solve high-school algebra "word problems." This program, called "Student," could solve problems like these:

The distance from New York to Los Angeles is 3,000 miles. If the average speed of a jet plane is 600 miles per hour, find the time it takes to travel from New York to Los Angeles by jet.

Bill's father's uncle is twice as old as Bill's father. Two years from now Bill's father will be three times as old as Bill. The sum of their ages is 92. Find Bill's age.

Most students find these problems much harder than just solving the formal equations of high-school algebra; that's just cookbook stuff. To solve informal word problems, you have to figure out what equations to solve, and to do that, you must understand what the words and sentences mean. Did Student understand? Well to begin with, it used a lot of tricks. It was programmed to guess that "is" usually means "equals." It didn't even try to figure out what "Bill's father's uncle" means—it only noticed that this phrase resembles "Bill's father." It didn't know that "age" and "old" refer to time, only that they're numbers to be put into equations. With a couple of hundred such word-trick facts, Student sometimes managed to get the right answers.

Then dare we say that Student "understands" those words? I feel no obligations to define such words as "mean" and "understand" just because others have tried to for 5,000 years! Our words are only *social things*; it's great when they combine to give us good ideas. But here, I think, words point to a maze of unproductive superstitions that only handicapped our predecessors when they tried to figure out what "meanings" are and how they get connected to words. That is a wrong-headed enterprise—like asking people to agree on what is "good" without considering each person's different hopes and fears.

We can't think very well about meaning without thinking about the meaning of something. So let's discuss what numbers mean. Take 5. Now, no one would claim that Bobrow's algebra program could be said to understand what numbers "really" are, or even what 5 really is. It obviously knows something of arithmetic, in the sense that it can find sums like "5 plus 7 is 12."

But does it understand numbers in any *other* sense—say, what five "is"—or, for the matter, what "plus" and "is" are? What would you say if I asked you, "What is five?" Early in this century, the philosophers Bertrand Russell and Alfred North Whitehead proposed a new way to define numbers. "Five," they said, is "the set of all possible sets with

The secret of what something means lies in the ways it connects to all other things we know.

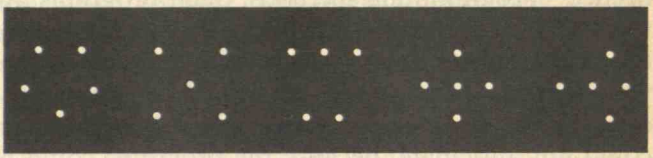
five members." This set included each set of five ballpoint pens and every litter of five kittens. Unhappily, it also includes such sets as "the five things you'd least expect" and "the five smallest numbers not included in this set"—and these led to bizarre inconsistencies and paradoxes. To make the idea work for mathematics—to get around these inconsistencies—made the Russell-Whitehead theory too complicated for practical, common-sense use. Educators once actually tried to make children use this theory of sets in the "new mathematics" movement of the 1960s, only further setting apart those who liked mathematics from those who dreaded it.

But the real trouble is with this theory's basic goal: finding some single, rigid definition for each word. That's fine for formalizing mathematics, but for real life, it ignores a basic fact of mind: *what something means to me depends to some extent on everything else I know*.

What if we built machines that weren't based on rigid definitions? Wouldn't they just drown in paradox, equivocation, inconsistency? Relax! Most of what people "know" already overflows with contradictions; we still survive. The best we can do is to be reasonably careful; let's just make our machines that carefully, too. If there remain some chances of mistake, well, that's just life.

Webs of Meaning

Let's go back to what numbers mean. This time, to make things easier, we'll think about three. I'm arguing that three has no one basic definition but is a web of different processes that depend upon one another. Consider all the roles "three" plays. One way we tell a three is to recite "one, two, three" while pointing to the different things. To do it right, of course, you have to (1) touch each thing once and (2) not touch any twice. One way is to count out loud while you pick up each object and remove it. Children learn to do such things in their heads or, when that's too hard, to use tricks like finger-pointing. Another way to tell a three is to use some standard set of three things. Then bring *your* set of things to the other set and match them one-to-one: if all are matched and none are left, then the three were three. That "standard Three" need not be things, for words like "one, two, three" work just as well. Yet one more way is to use perceptual groups—to think of three as groups of one and two, as a triangle, or in a line. For five we have a wider choice: to think of groups of two and three, or one and four, or a pentagon, a thing-filled square, a "w" star, a plane; they all make five.



Because each trick works in different situations, our power stems from being able to shift from one trick to another. To ask which meaning is correct—to count, or match, or group—is foolishness. Each has its uses and its ways to support the others. None has much power by itself, but together they make a versatile skill system. Instead of being links in flimsy chains of precise definitions in the mind, each word can activate big webs of different ways to deal with things, to use them, to remember them, to compare them, and so forth. This is good for solving problems, since when any sense of meaning fails, you can switch to another. With multiply-connected knowledge nets, you can't get stuck. But if you use the mathematician's way of single, precise definitions, once you get into the slightest trouble, you're stuck for good.

Why, then, do mathematicians stick to slender chains of logic, with each link depending on as few things as possible? The answer is ironic: mathematicians want to get stuck. When anything goes wrong, they want to be the first to notice it. The best way to be sure of that is having everything collapse at once. To them, fragility is good, not bad, because it helps them find perfect proofs and no single thing they think can be inconsistent with any other. That's fine for mathematics; in fact, that's what much of mathematics is. It's just not good psychology. Let's face it; our minds will always hold beliefs that turn out to be wrong.

I think it's bad psychology when teachers shape our children's mathematics into long, thin, fragile, definition tower-chains instead of robust, cross-connected webs. Those chains break at their weakest links, those towers topple at the slightest shove. And that's what happens in math class to a child who only takes a moment to watch a pretty cloud go by. Perhaps that's why our culture makes most children so afraid of mathematics. We think we help them get things right by making things go wrong most times.

Our conscious minds must be like high executives who can't be burdened with the small details.

Perhaps, instead, we ought to help them build more robust networks in their heads. In real life, the best ideas are as cross-connected as can be.

Castles in the Air

The secret of what something means lies in the ways it connects to all the other things we know. The more such links, the more a thing will mean to us. The joke comes when someone looks for the "real" meaning of anything. For, if something had just one meaning—that is, if it were connected to just one other thing—then it would scarcely "mean" at all. That's why I think we shouldn't program our machines that way—with clear and simple logic definitions. A machine programmed that way could never "really" understand anything, any more than a person would. Rich, multiply connected networks provide enough different ways to use knowledge that when one way doesn't work, you can try to figure out why. When there are many meanings in a network, you can turn things around in your mind and look at them from different perspectives; when you get stuck, you can try another view. That's what we mean by thinking.

The question of whether computers can "understand" meaning is really not about computers at all but about our foolish quest for meanings that stand by themselves, outside any context. Our questions about thinking machines should really be questions about our own minds. The networks in our human minds are probably more complex than any other structure science ever contemplated. As a result, the detailed programs of artificial intelligence will eventually need some very complicated theories.

Is there some paradox in this idea, that every meaning is built on other meanings, with no special place to start? If so, then isn't all a castle built on air? Well, yes and no. Contrary to common belief, there's really nothing wrong with circular definitions. Each part can give some meaning to the rest. There's nothing wrong with liking several different tunes, each one the more because it contrasts with the others. There's nothing wrong with ropes—or knots, or woven cloth—in which each strand helps hold the other strands together (or apart). There's nothing very wrong, in this sense, with having one's entire mind a castle in the air.

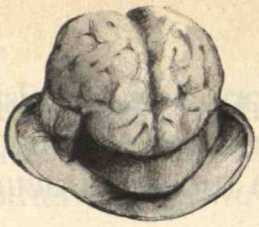
But then how could such a mind have any contact with reality? Well, maybe this is something we must always face, be we machine or human. In the human condition, our mental contact with the real world is really quite remote. The reason we don't notice this, and why it isn't even much of a potential problem, is that the sensory and motor mechanisms of the brain (that shape the contents of, at least, our infant minds) ensure enough correspondence between the objects we perceive and those that lie out there in raw reality—enough so that we hardly ever walk through walls or fall down stairs.

But in the final analysis, our idea of "reality" itself is rather networky. Do triangles "exist" or are they only threes of lines that share the vertices? "Reality" itself is also somewhat like a castle in the air. And don't forget how totally some minds, for better or usually for worse, do sometimes split away to build their own imaginary worlds. When we build intelligent machines we'll have a choice: either we can constrain them as we wish to match each and every concept to the outside data we provide, or we can let them build their own inner networks and attain a solipsistic isolation totally beyond anything we humans could conceive.

Are Humans Self-Aware?

Most people assume that computers can't be conscious, or self-aware—that at best they can only simulate the appearance of this. Of course, this assumes that we, as humans, are self-aware. But are we? I think not. I know that sounds ridiculous so let me explain. If by awareness we mean knowing what is in our minds, then as every clinical psychologist can tell you, people are only very slightly self-aware, and most of what they think about themelves is guesswork. We seem to build up networks of theories about what is in our minds, and we mistake these apparent visions for what's really going on. To put it bluntly, most of what our "consciousness" reveals to us is just "made up." Now, I don't mean that we're not aware of sounds and sights, or even of some parts of thoughts. I'm only saying we're not aware of much of what goes on inside our minds.

When people talk, the physics is quite clear: our voices shake the air, which makes our eardrums move, and then computers in our head convert those waves into constituents of words. These somehow turn into strings of symbols representing words, so now there's something in our heads that represents a sentence. In the same way, when we see something,



the waves of light excite our retinas, and this causes events in our brains that correspond to texture, edges, color patches, and the like. These, in turn, are somehow fused to "represent" a shape or outline of a thing. What happens then?

Society's standard concept is of a little person hiding inside our brain who hears or reads the sentence, someone who understands what's going on. Call it the "single-agent theory": deep inside each mind resides a special "self" that does the real mental work for us. It isn't hard to see why every culture gets attached to this idea. No matter how ridiculous it may seem scientifically, it underlies all principles of law, work, and morality. Without this idea of a single self, we would have no canons of responsibility, no sense of blame or virtue, no sense of right or wrong. Without that myth, how could we have societies at all?

The trouble is, we cannot build good theories of the mind that way. Just as science is forced to accept the fact that what we think are single things—such as rocks or mice or clouds—must sometimes be regarded as other complicated kinds of structures, we'll simply have to understand that the self, too, is no "elementary particle" but an extremely complicated construction.

It is easy to say things like, "Computers can't do X because they have no self—no feelings or thoughts." But if we shed the single-agent theory, such sayings turn into foolishness: "Computers can't do X because all they can do is execute incredibly intricate processes, perhaps millions at a time." Such objections now seem less convincing, yet all we did was face one simple truth. We really don't yet know what the limits of computers are. Now let's face the other fact: that our notions of the human mind are just as primitive. Why are we so reluctant to admit how little we know about how the mind works? It must come partly from the human tendency to repress knowledge that seem to upset the established order.

But there are deeper reasons, too, for wanting to believe in the uniqueness and inexplicability of self. Perhaps we fear that too much questioning might tear the veils that clothe our mental lives. To me, there is a special irony when people say machines cannot have minds, because I feel we're only now beginning to see how minds could possibly work, using insights that come directly from attempts to see what complicated machines can do. Of course, we're nowhere near a clear and complete theory—yet. But in retrospect, it now seems strange that we could ever hope to understand how minds work before we knew much more about machines. (Except, of course, if you believed that minds are so different from anything else that there's no use trying to understand them.)

Now, you might ask, if the ordinary concept of self is so wrong, what would I recommend in its place? For social purposes, I don't recommend changing anything—it's too risky. But for the technical enterprise of making intelligent machines, we need better theories of how to "represent," inside computers, the kinds of webs of knowledge and knowhow that figure in everyone's common sense. We must develop programs that know, say, what numbers mean, instead of just being able to add and subtract them. We must experiment with all sorts of common-sense knowledge, including knowing what kind of knowledge to use on what kinds of problems.

Such is the focus of some present-day AI research. Although most of the world of "computer science" is involved with building shallow but practical systems, a few courageous students are trying to make computers use other kinds of thinking. They are writing programs that represent different kinds of knowledge in several different ways, so that the computer won't get stuck on fixed ideas. Most important of all, perhaps, is making such machines learn from their own experience. Once we know more about such things, we can start to study ways to weave these different schemes together. Finally, we'll get machines that think about themselves and make up theories, good or bad, of how they themselves might work. We may find it very easy to tell when our machines get to that stage, for they'll probably object to being called machines. Accepting that will be difficult, but only by this sacrifice will machines free us from our false mottos.

The Complexity of Child's Play

We've all enjoyed those jokes about the stupid and literal behavior of computers. They send us silly checks and bills for $0.00. They can't tell when we mean "hyphen" from when we mean "minus." They don't mind being caught in endless loops, doing the same thing over again a billion times. This total lack of common sense is one more reason people think that no machine could have a mind. It's not just that they do only what they're told; it's also that they're so

Continued on page 80

SCIENCE/SCOPE

The first electro-optical use of a flexible machining system will be for manufacturing large numbers of ultra-precision optical housings. The new Hughes Aircraft Company "flex-fab" system is a combination of nine computer-controlled milling machines connected by carts that are pulled on an endless chain towline built into the floor. Each machine has 68 different tools to choose from. Altogether there are 612 tools available, enabling flex-fab to do the work of 25 individual machines. At first, flex-fab will machine aluminum chunks into housings for TOW antitank missile systems with an exactness to one thousandth of an inch. Soon, design engineers will be able to ask flex-fab to build parts, thus eliminating the need for blueprints.

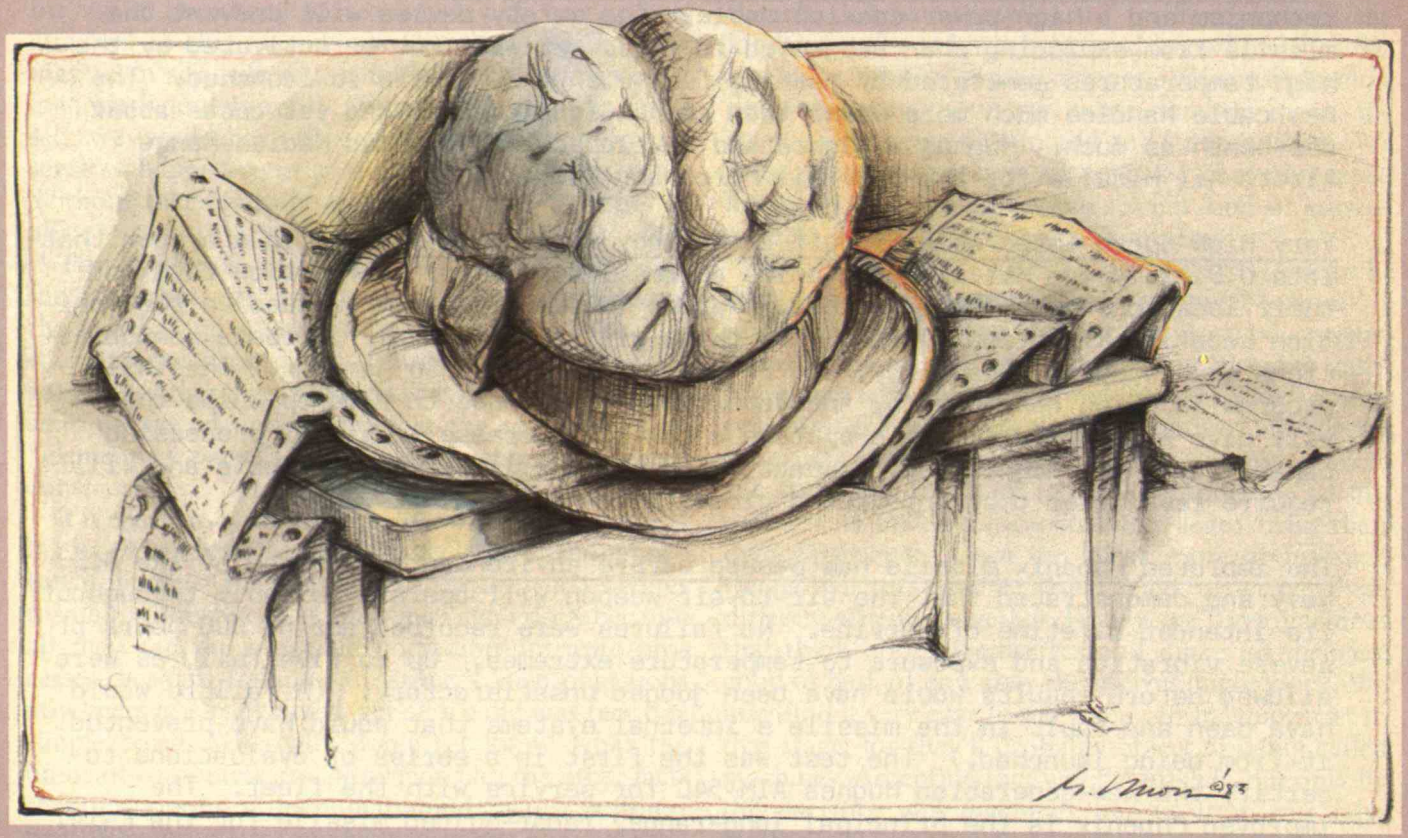
Among many innovations built into the new AMRAAM missile are a special safety mechanism and a high-power coaxial cable. The safety device will prevent the missile from exploding when subjected to fire, yet will not be activated by the high temperatures generated by burning fuel when the missile is launched. The new cable handles much more power than conventional cables and yet costs about one-tenth as much. Hughes designed and developed the Advanced Medium-Range Air-to-Air Missile for the U.S. Air Force and Navy.

Very High Speed Integrated Circuit technology will be introduced in a system that lets U.S. Army and Marine Corps units automatically report navigation data and their locations to command centers. Hughes VHSIC chips will be used in the Position Location Reporting System. The chips will significantly increase communications and encoding capability, and reduce vulnerability to jamming. The VHSIC program is being conducted by the Department of Defense to develop chips that will give military electronic systems a tenfold increase in signal processing capability. The high-speed, compact VHSIC chips will be more reliable and will require less power than integrated circuits now in use.

The improved Phoenix missile has passed severe environmental testing by the U.S. Navy and demonstrated that the air-to-air weapon will operate reliably throughout its intended lifetime of service. No failures were recorded during 600 hours of severe vibration and exposure to temperature extremes. Up to five failures were allowed before results would have been judged unsatisfactory. (A failure would have been any fault in the missile's internal systems that would have prevented it from being launched.) The test was the first in a series of evaluations to certify the new-generation Hughes AIM-54C for service with the fleet. The improved Phoenix is the principal long-range, radar-guided missile for the F-14.

Hughes Missile Systems Group, located in Canoga Park, California, an attractive suburb of Los Angeles, is seeking engineers and scientists for such developmental and engineering programs as AMRAAM, multimode guidance, Phoenix, and IR Maverick. Openings are in radar and electro-optical systems design, systems software and hardware/software integration, analog and digital circuits design, hybrid process engineering, and systems performance. Qualified applicants are assured prompt replies. Please send resume to Hughes Engineering Employment Manager, Dept. SE, Fallbrook at Roscoe, Canoga Park, CA 91304. Equal opportunity employer.

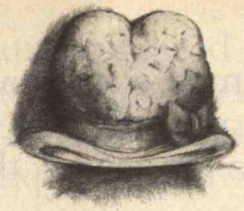
Expert Systems: The Practical Face of Artificial Intelligence



BY JOEL N. SHURKIN

"We should give ourselves credit for having the intelligence to recognize our limitations and for inventing a technology to compensate for them."

ILLUSTRATION: GEOFFREY MOSS



A doctor in a remote village in Alaska has a patient in serious condition but lacks the expertise to make a diagnosis and prescribe treatment. So plugging a portable computer terminal into a radio, the doctor connects via satellite to a computer several thousand miles away. The computer contains a vast database of internal medicine and a program that emulates all the reasoning power and experience of medical authorities. The computer is the expert, which the doctor in the Alaskan village, or health workers anyplace else, can consult instantaneously.

The gap between that dream and today's reality is huge, and the dream has probably been oversold. But scientists are beginning to make great strides in producing expert systems—programs that incorporate the expertise of humans in a computer. Indeed, the potential power of systems that can replicate expensive or rare human knowledge has led to a worldwide effort to extend and apply this technology.

About 200 researchers in the United States—500 worldwide—are working on these programs, and there are about 50 programs that qualify as expert systems. A number are commercially available, and a half-dozen actually make money for their developers. Expert systems are being used in such disparate fields as medicine, business management, computer design and repair, and the search for natural resources. These systems can be used in a variety of ways. "Expert systems can be experts—you come to them for advice," says Randall Davis of M.I.T. "Or they can be coworkers, on a more equal footing. Or they could be assistants to an expert. All along the spectrum there are very useful systems that can be built."

A frantic race is also underway to produce the next generation of expert systems and the computers to run them. Stanford University's Edward Feigenbaum, borrowing from Adam Smith, calls the potential of artificial intelligence the "new wealth of nations." Artificial intelligence includes not only expert systems but robotics, speech recognition, image analysis, and the pursuit of what can only be described as epistemology—the study of human intelligence in an attempt to formulate rules that explain how humans think.

First Thoughts of Thinking Machines

The earliest attempt to emulate human thought in a machine may be attributed to Ada Augusta Byron, the daughter of Lord Byron. She was, arguably, the first computer programmer. In mid-nineteenth-century Britain, she helped Charles Babbage design the logic for a proposed mechanical computer, which he called the Analytical Engine. Such a machine, "programmed" using replaceable loops of punch cards (an idea adopted from automatic looms), was designed to draw conclusions and proceed on the basis of them. When the machine finished one series of operations, it would look at the results and decide for itself what to do next. If the result of a certain calculation fit into a particular range, for instance, the machine would do one thing; if the total did not, the machine would do something else. That way, the machine could weave through a complex of decisions. However, Babbage, who hardly ever finished anything, never finished the Analytical Engine.

Modern scientists required great leaps in concept and technology before they could seriously try to create artificial intelligence. The technological breakthrough came when J. Presper Eckert and John Mauchly of the University of Pennsylvania produced ENIAC, the first electronic general-purpose digital computer. Developed during World War II, the machine was kept a military secret until 1946. The work of many scientists converged at about this time. And newer machines, which could remember superhuman quantities of information and be easily reprogrammed, enabled scientists to devise complex programs to solve complex problems. Scientists could also begin to fulfill their long-standing dream of simulating thought and reasoning symbolically.

In fact, many were convinced that any process of the human mind could be reproduced in computing machines. For example, in 1947 British scientist Alan Turing proposed building an intelligent machine, and he even devised a test to determine when computers could be said to think. The Turing Test would put a human expert at the keyboard of a computer to ask questions. Some of the questions would be answered by the computer, some by another human expert via the computer. If the tester could not tell when the human or the machine was answering, the computer could be said to possess intelligence. Of course, today's computers can already fool experts, and most computer scientists now think the Turing Test is too easy.

Artificial intelligence was born as a science in 1956 at a meeting at Dartmouth College. Marvin Minsky, now at M.I.T., John McCarthy, now at Stanford, Nathaniel Rochester of IBM, and Claude Shannon of Bell Laboratories instigated the meeting to discuss ways of simulating thought with computers. The meeting not only gave birth to the term "artificial intelligence," or AI, but also featured the announcement of what many consider the first real computer program in AI—the first expert system.

The program, called Logic Theorist, was developed by Allen Newell and Herbert Simon of Carnegie-Mellon, and J.C. Shaw of the Rand Corp. They had used the program to prove several mathematical theorems proposed by Alfred North Whitehead and Bertrand Russell in *Principia Mathematica*, and, in at least one case, the program provided a more elegant proof than the one devised by the human mathematicians. Ironically, the scientists ran into trouble when they tried to publish their achievement; no journal wanted to accept a paper with a proof thought up by a machine.

The Shift to Rules of Thumb

Since then, researchers developing expert systems have tried to pick the brains of experts in many fields, put that knowledge into computer programs, and get computers to come to the same conclusions as the experts, preferably using the same cognitive methods—no mean task. Their approach has changed considerably over the years. At first AI research was dominated by a naive belief that a few laws of reasoning coupled with powerful computers would produce expert performance. But scientists soon found these "general-purpose" problem-solving strategies were too weak to handle most significant problems. The dilemma is that computers are fantastic devices for run-

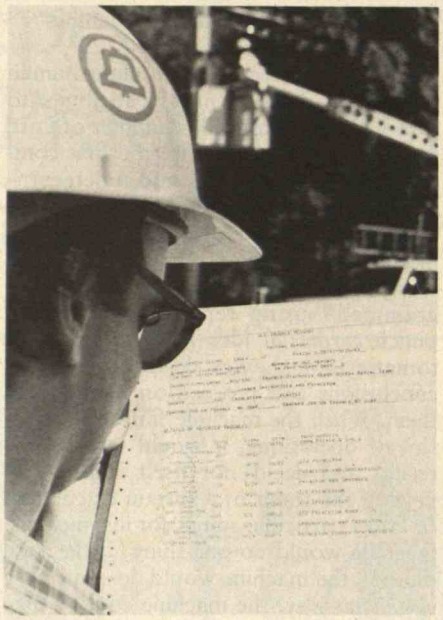
While most expert systems are still experimental, a number are in everyday use and some even make money for their developers.

ning through bits of information one by one, comparing them, adding, subtracting, moving them about. Indeed, some computers appear to be bright because they do this at phenomenal speed. But little of human intellect can be simulated that way.

Consider the game of chess. An almost infinite number of moves are possible. The world's fastest computer, working full-time, could conceivably consider all the potential moves early in a game in about a decade. This method, which programmers call "brute force," is useless for problems of this type. Thus, scientists have developed programs that take short-cuts. These programs consider only the most likely moves, weigh their potential based on the computer's storehouse of chess knowledge, and determine which move is best. The computer must exercise judgment just as human chess champions do. This judgmental knowledge is called "heuristics," from the Greek word for discover, and AI researchers now usually consider heuristics the method of choice in designing expert systems.

Heuristics has been called the "art of good guessing." It enables experts, human or machine, to recognize promising approaches to problems, to break problems down into smaller problems, to get around incomplete data, and to make educated guesses when necessary. Thus, knowledge, combined with the rules of thumb that human experts gain from experience and use in solving problems, is considered more important than formal reasoning methods. To use heuristics, programmers have had to develop whole new families of computer languages. One of the most common is called Lisp, for List Processing, a language that is especially proficient at manipulating symbols in addition to numerical data.

Unlike conventional computer languages, AI languages incorporate data into the instructions in such a way that new knowledge can be added to the program without extensive reprogramming. Conventional programs also instruct a computer to solve a problem by following a rigid series of steps called an algorithm. However, this clearly isn't the way humans think and falls short when a problem requires "reasoning." Many expert systems use what are called "if-then" induction statements. For example, *if* a person has a running nose, a temperature, and is sneezing, *then* the person has a cold. A followup step in the program might be: *if* the patient has a cold, *then* prescribe aspirin. Another common way of representing knowledge is a pyramid-shaped network of related ideas called a "semantic network," which deduces conclusions. For example: all birds have wings, a sparrow is a bird, therefore a sparrow has wings. In the case of semantic networks, facts are clumped together in "nodes" and interconnected by all possible paths, which if followed leads to a conclusion—the top of the pyramid.



Repair crews in Fort Worth use the "decisions" of an expert system to maintain telephone cables. Each night the program, developed by Bell Labs and called Ace (for "automated cable expertise"), examines crew reports to determine what repairs are needed where—a job that would take a week for a human.

Computerized Chemist

The first program to use heuristics came from a conversation at Stanford between Edward Feigenbaum and Joshua Lederberg, Nobel Prize-winning geneticist. Feigenbaum wanted to see if he could emulate in a computer the kind of empirical deduction common to the scientific process. Lederberg suggested beginning with the analysis of organic compounds using mass spectroscopy, a well-established technique for identifying molecules by analyzing the spectrum produced when each element in the molecule absorbs light. Lederberg immersed himself in computer science and also recruited Carl Djerassi, a respected professor of chemistry at Stanford. They began in 1965, and they eventually produced Dendral, the first commercial expert system.

The task seemed enormous. They had to determine the basic concepts involved and develop rules that express the relationships between concepts. A major part of the challenge was for the computer specialists to find out what Lederberg and Djerassi knew and how they knew it, and then to convert that information into symbols—a give-and-take process that took several years. This technique for translating an expert's experience into symbols that computers can understand has come to be called "knowledge engineering." Dendral worked, has been expanded to include data from other analytical techniques such as nuclear magnetic resonance, and is now used regularly by organic chemists around the world.

The success of Dendral helped convince computer scientists that systems using heuristics could indeed mimic the way experts solve problems. It also provided encouragement that such "rule-based" programs would work in fields other than organic chemistry. At Stanford, researchers decided to try again with something even more complex—medicine.

Designing Doctors

Edward Shortliffe, a Harvard-educated premed with a passion for computers, found himself at Stanford studying computer science and medicine. His advisor was Stanley Cohen, soon to be famous for his work on recombinant DNA. Shortliffe produced a program—incorporating the expertise of Cohen and physician Stanton Axline—that would diagnose blood and meningitis infections and advise physicians on antibiotic therapies. The program, called Mycin, performed at the level of human specialists in infectious diseases and above the level of nonspecialist physicians. Mycin had other problems that limited its usefulness in clinical situations, but it served well as a lesson in knowledge engineering.

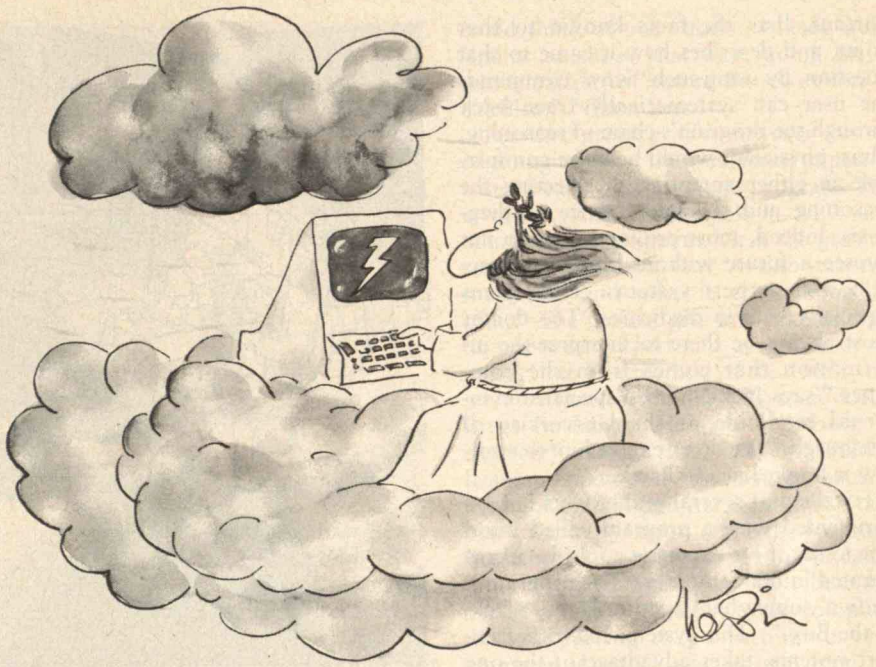
PHOTO: BELL LABORATORIES

Heuristics, called the "art of good guessing," is widely considered the method of choice in designing expert systems.

"We'd get together once a week and go over patient cases, and we would try to understand how Axline and Cohen would decide how to treat those cases," Shortliffe says. "We'd stop them—those of us who knew a litte medicine and were more computer scientists—and ask, 'well, why do you say that?' Axline would have a patient's chart, and Cohen would ask him questions. Axline would answer them from the chart. Cohen would try to figure out what he'd do for that case, and we would try to understand why Cohen was asking the questions he was. We'd write down the rules that he'd tell us, which Axline would help refine, and in the interim week I'd put those rules into the emerging computer program."

The computer would then try its skill at the cases, and the researchers would sit around as the computer made a long string of stupid mistakes. Humans approach decision making with a lifetime of experience and common sense behind them; computers have neither. Computers also lack a context in which to place information unless the programmers provide them with one. For example, a computer could easily produce the diagnosis "he is pregnant," unless humans thought to warn it only females could get pregnant. Shortliffe then went through the painful process of refining the program—each mistake had to be traced and the cause corrected.

This took longer than writing the rules. "Plus," Shortliffe adds, "every once in a while some issues would arise which caused a major change in the underlying structure of the program." One problem the researchers faced is that in the real world A plus B might equal C, but not always, and not always with the same plausibility. "Inferences were not logical inferences so much as plausible inferences," Shortliffe says. The computer had to be able to weigh the decisions by their plausibility. For example, if a patient has a fever it is possible he has a cold. It is also possible that he has a hundred other things, so the fact of a fever is given certain weight. If the patient also has a running nose and a cough, the diagnosis of a cold becomes highly plausible. So when Shortliffe sat down with Axline and Cohen, he needed to know not only what they knew, but he had to get their judgment on the plausibility of conclusions and the interconnections between facts.



The ultimate expert

What Makes an Expert?

In developing Mycin, the researchers found something surprising. If they removed the knowledge base from the program—that is, removed the medical information—what they had left was a section that contained the logic. That section seemed almost universal. You could plug in databases from other fields, say geology or computer-chip design, and the program would still work. The researchers now call this logic portion the "inference engine" (shades of Babbage), and they have developed a program incorporating this generalized logic named Essential Mycin, or Emycin. Indeed, IBM is using an expert system based on Emycin to diagnose malfunctions in computer disk drives. And Sacon (structural analysis consultant) is an Emycin-driven system that assists structural engineers in identifying the best strategy for using a complex computer simulation program.

The ability of the inference engine to operate in several fields supported the notion that at least some human reasoning is structural and can be duplicated by a machine. It has also led to some serious thought about the nature of expertise and what researchers want from expert systems. For example, M.I.T.'s Davis counts seven attributes of experts: They can solve problems. They can explain the results. They can learn by experience. They can restructure their knowledge. They are able to break rules when necessary. They can determine relevance. And their performance "degrades gracefully" as they reach the limits of their knowledge.

So far expert systems exhibit only the first three properties in any depth. Of these, Davis says pure problem solving "is still the best understood; our efforts at explanation and knowledge acquisition (learning by experience) have only scratched the surface." Consider explanation. One of the drawbacks of early medical expert systems was that physicians would not trust the computer's results. Programmers realized that users had to be able to query the computer to determine if the reasoning was valid.

At Stanford, researchers added a program called Teiresias to Mycin that kicks in when a physician types the word "why." For example, in working through a particular patient's case the computer might ask if the infection is hospital-acquired. If the physician then queries why Mycin asked that question, Teiresias explains why it thinks that might be im-

Knowledge engineering, the transfer of expertise from specialist to computer program, is a critical bottleneck in AI research.

portant, lists the facts known to that point, and describes how it came to that question. By using such "why" commands the user can systematically trace back through the program's chain of reasoning. Thus, physicians would be more comfortable in either accepting or rejecting the reasoning and the later advice or diagnosis. Indeed, most programmers do not foresee a future without human interaction with expert systems. This seems especially true in medicine. "The doctor must always be there to interpret the information that comes from the computer," says Jack Myers, a specialist in internal medicine at the University of Pittsburgh. "We don't expect him to swallow it hook, line, and sinker."

For the past several years Myers has experimented with a program called Internist to see if his expertise could be incorporated into a computer. (The program is known somewhat facetiously as "Jack-in-the-Box.") This system, like other expert systems, takes advantage of the one aspect in which computers are vastly superior to humans—memory. "The human memory is just not big enough to deal with the modern medical knowledge base," says Myers. "The brain is not capable of entertaining an adequate number of simultaneous hypotheses, so the physician has to have a crutch."

Internist's database includes information on about 500 diseases, about 75 percent of all major medical diagnoses. To see how good Internist was, Myers and computer scientist Harry E. Pople, Jr., entered hundreds of cases into the program, taken from the *New England Journal of Medicine*. Panels of physicians and experts were matched against the computer. Nineteen cases involving 43 different diagnostic problems were chosen for the test. Internist was right 25 times, while the physicians who had tended the patients were right 28 times, and clinical experts were correct 35 times. Internist did miss some diagnoses, but it generally did as well as most ordinary physicians. Moreover, no previous diagnostic system could have even begun to handle such a large number of complex cases drawn from the broad field of internal medicine.

Still, Pople and Myers are developing an improved program, called Caduceus after the serpent-entwined symbol of physicians. Among the improvements, the program has been equipped with a model of the human body and its workings; thus, Caduceus can make inferences based on the interactions of different organs and can follow the progression of disease symptoms over time. Caduceus first takes the history of the patient, the symptoms, and the results of an examination and tests. The program then goes into its memory banks to select possible diagnoses. First it measures "evoking strength," the likelihood that a particular patient is suffering from each possible disease. The likelihood is decreased by a determined amount if certain symptoms are missing. The computer then presents the doctors with several possible diseases to let them know what it is thinking about. Using heuristics, it has eliminated all the other diseases from consideration. For instance, if a patient does not have a temperature, the program would throw out all diseases that require a fever in its list of symptoms.

"SO MUCH FOR NEWTON. NOW, AS FOR EINSTEIN..."

Caduceus then tries to narrow the field by asking a series of questions. It might ask for the results of further blood tests, suggesting that the physician order them if he has not already done so. The program might ask for more history, or genetic information. The answers to each question help recalculate the evoking strength. When one disease winds up with a convincing margin over the others, Caduceus announces its diagnosis.

However, Caduceus is still not finished with its work. The program then eliminates all the symptoms and factors that led to that diagnosis and goes back over its data to see if remaining medical problems could be explained by another illness. This goes on until all the symptoms and abnormal test results can be explained.

The program is still being tested at Pitt's School of Medicine, and Myers and Pople say Caduceus is not yet ready for routine use in other hospitals. For example, they need to add information about other diseases. And the program cannot yet recognize new or unfamiliar illnesses; Myers says the program will claim the disease doesn't exist, while a human physician is open to new possibilities.

Expert Systems in the Marketplace

While most expert systems are still experimental, some are in day-to-day use. For example, a simplified medical-diagnosis program, an offshoot of Mycin called Puff, is being used at the Pacific Medical Center in San Francisco to diagnose lung disease. And Stanford has set up a national computer network called SUMEX-AIM just for AI work in medicine. Research groups around the country can time-share on the SUMEX-AIM machine instead of having to buy their own.

Prospector, developed by SRI International for the U.S. Geological Survey, is used for mineral exploration. The program contains knowledge derived from many geologists who were each authorities on a different class of ore deposits. Prospector can evalute the potential of a geographical area for a particular kind of ore, a particular exploration site within that area, and different drilling sites in the exploration area. It can also explain how it reached its conclusions and indicate what information is most valuable for further exploration. Since Prospector is an expert on finding a number of different kinds of minerals, it can outperform any single human expert. Indeed, Prospector marked its first success recently when geologists used it to discover a molybdenum deposit in Canada worth millions of dollars.

Teknowledge, Inc., of Palo Alto, has a program to help oil companies decide what to do when a well bit gets stuck. Today oil companies must fly highly paid experts all over the globe to handle drill-

DRAWING: SIDNEY HARRIS

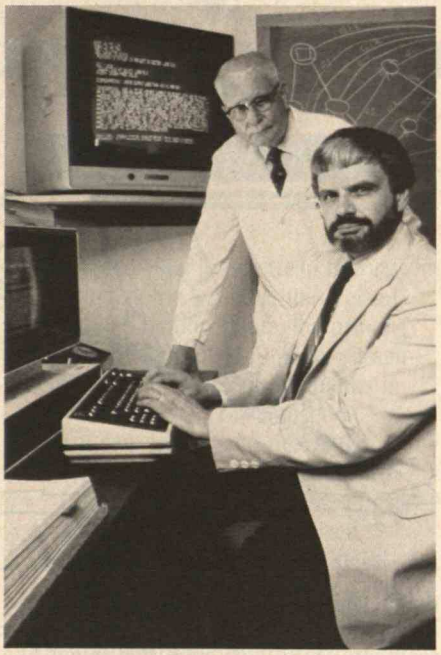
Many scientists believe advanced expert systems and the emerging supercomputers will bring about a second computer revolution even more important than the first.

ing problems as they occur. And since an idle drilling rig represents a loss of perhaps $100,000 a day, having an expert system can be most valuable. Cognitive Systems of New Haven sells a program to help insurance agents develop the best policies for their customers.

Bell Laboratories has an expert system working in Fort Worth that analyzes repair reports from the crews who fix telephone cables. Every night the program, called Ace, diagnoses specific cable trouble spots and suggests what repairs will be needed—a job that would take a week for a human. John McDermott of Carnegie-Mellon worked with researchers at Digital Equipment Corp. to develop R-1, which helps the company in building its VAX computers. The computers are almost always customized to conform to specific users' needs, which means large numbers of components must be put together subject to many constraints and conditions. A variant of R-1, called Xsel, is being tested by DEC salespeople to ensure that mistakes are not introduced at the time of order, since the company may have to bear the cost of correcting a computer once the order is accepted.

Perhaps the best evidence that AI and expert systems are taken seriously is that dozens of companies have invested heavily in research on the programs. IBM, Bell Laboratories, Xerox, Hewlett-Packard, Schlumberger, and Texas Instruments are just a few. And many new companies have been formed, often by the academic researchers themselves. Indeed, there is growing unease about the number of university researchers who are being pulled into business as industry becomes more involved with AI. This aggravates what is already a shortage of trained AI personnel, a factor that some see as holding back progress in the field.

Also holding up further advances in expert systems are limitations in hardware and software. AI researchers are anxiously awaiting the so-called fifth-generation computers, many of which will use multiple processors to gain faster access to their huge memory banks, instead of merely pulling the data out one item at a time. There seems little doubt that this is workable; some current "supercomputers" such as the Cray use multiple processors, although not as many as fifth-generation models will use. However, there is considerable worry over who will get the fifth-generation computers first, since Japan is devoting nearly half a billion dollars to developing advanced computers targeted specifically at AI applications.



"The human memory is just not big enough to deal with the modern medical knowledge base," says Dr. Jack Myers (left) of the University of Pittsburgh. So he and computer scientist Harry Pople are developing Caduceus, an expert system that diagnoses a wide range of diseases. Caduceus, still being improved and tested, did about as well as ordinary physicians and slightly worse than clinical experts in early trials.

Scientists also need better programming languages to represent knowledge. For example, current languages rarely capture subtleties and sometimes fail to reflect major aspects of an expert's knowledge. Nils Nilson of SRI International, former president of the American Association for Artificial Intelligence, says, "What we'd like to do in AI is represent the knowledge a person can easily say in English, but represent it as precisely as you do in mathematics." Scientists at Stanford, M.I.T., Carnegie-Mellon and other research centers are working on a variety of knowledge-representation languages. "You could think of our efforts as being quite similar to those that were going on in mathematics just before the invention of calculus," Nilson says.

Another problem is improving knowledge engineering, the transfer of expertise from specialist to computer program. This is the "critical bottleneck in AI," says Stanford's Feigenbaum. "It is the greatest research problem that AI laboratories must face and solve in the coming decade." The present give-and-take interaction between expert and programmer remains "the best method of the 1980s, but it is very time consuming," says Stanford's Bruce Buchanan. He says a "knowledge engineer" can get the basic information from an expert and other sources such as textbooks in about a week, but it can take many worker-years to refine the program. Buchanan is working on a concept called "knowledge acquisition," in which the expert would talk directly to the computer without having to go through a programmer. Another way of educating the computer is to have it learn from its mistakes. In most of today's expert systems, humans must catch the errors and modify the programs.

The $64 Question

Nothing as complicated as expert-system and AI research can go without controversy. For example, researchers haven't yet agreed on whether programs should strive to actually emulate the reasoning of the human brain. Some scientists are taking that approach, while others maintain that the effort is wasteful. The latter point out that the Wright brothers didn't try to emulate birds to produce a flying machine.

An even larger debate centers on whether expert systems enable computers to really think. Nobel laureate Herbert Simon, an AI pioneer at Carnegie-Mellon, believes they do. "I occupy one of the extreme wings on this," he says. "The way we tell if a human being is intelligent is to give him certain tasks and see what he does with them. Intelligence has to do with the ability to respond appropriately to complex situations. Every time we write a computer program to do that, particularly if it's a fairly general program, I find it quite natural to speak of the computer as exhibiting intelligence."

Some, like Douglas Hofstadter of In-

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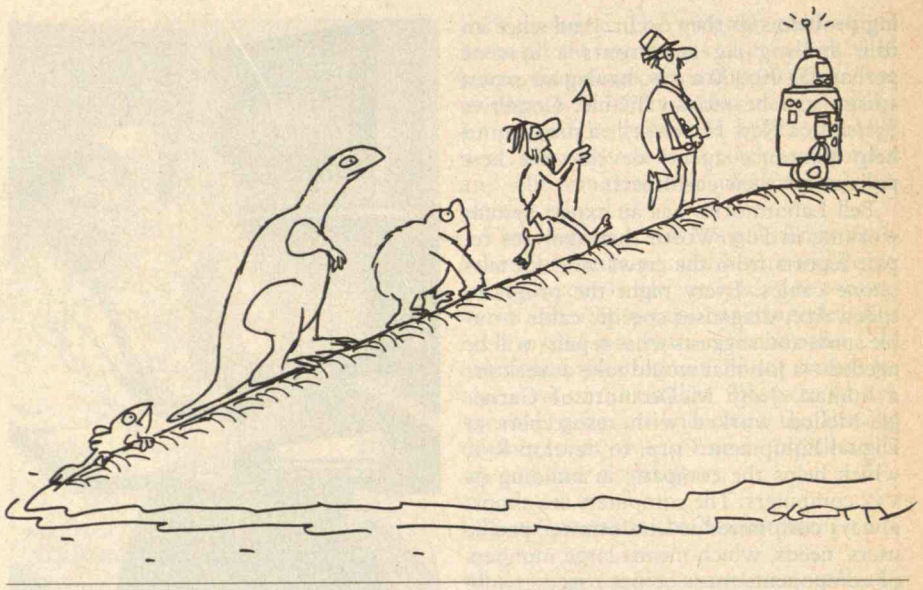


diana University, maintain they do not. Hofstadter believes that most AI researchers are so busy imitating things like logic and deduction that they have spent almost no time working on the more subtle things that constitute human intelligence, such as intuition. "It is my belief," he says, "that until AI is stood on its head and is 100 percent bottom-up, it won't achieve the same level or type of intelligence as humans have."

Marvin Minsky of M.I.T. thinks the present expert systems have gone as far as they can go, and AI researchers are going to have to go back to basics, or "First Principles." "These programs are exciting but most of them are not very deep," he says. "You don't see researchers working on the problem of common-sense reasoning, for instance. There is no program around today that will tell the difference between a dish and a cup."

In the meantime, AI researchers agree that existing programs are only the beginning—"experimental prototypes," as Feigenbaum describes them. "They work well because the tasks have been highly constrained to the point where we can accumulate enough knowledge to make a difference in problem solving," he says. "To expand over the whole world of knowledge, to encompass as much knowledge in these machines as possible, the machines need to become smarter, by which I mean better problem solvers."

Many scientists believe advanced expert systems and the emerging supercomputers will bring about a second computer revolution, even more important than the first. For example, Raj Reddy of Carnegie-Mellon finds almost a manifest destiny in this sort of work. Reddy said at this year's American Association for the Advancement of Science meeting that humanity is the only species that has used artifacts—"extragenetic techniques"—to progress. "What you see now is the next stage of human evolution," he said. "If you can build an artifact that can permit you to think and act hundreds of times faster than you're currently able to, you will be that much further ahead in the evolutionary processes."

Edward Feigenbaum also sees the coming of a new age. "We humans are very good at converting sensory signals to cognitive signals and at solving problems that require common sense," he says. "But in the face of large amounts of data we quail: we are unsystematic and forgetful, grow bored, get distracted. Writing and book technology helped us overcome some of those problems; interactive smart computers will help some more. We should give ourselves credit for having the intelligence to recognize our limitations and for inventing a technology to compensate for them."

JOEL N. SHURKIN is a science writer and instructor in communications at Stanford. His book on the history of computers, Engines of the Mind, *will be published in February 1984 by W.W. Norton.*

DRAWING BY SCOTT VALENTINE, COURTESY OF OMNI MAGAZINE

THE FIRST AMENDMENT v. UNION POLITICAL SPENDING

The First Amendment was written nearly 200 years ago to protect the right of all Americans to freely express their own opinions—and the right not to support opinions with which they disagree.

But despite the First Amendment, one group in America has the power to force men and women to financially support political causes and candidates they oppose—or lose their jobs. That group is organized labor.

Federal labor law as well as some state laws permit unions and employers to require working Americans to pay union dues as a condition of employment, regardless of whether or not they want to join or support a union. As a result, the AFL-CIO and member unions collect more than $3.5 billion per year—$10 million a day—in compulsory dues.

This massive amount of union treasury money, often called "soft money," cannot be used for direct cash contributions to candidates for federal office. But federal election law permits the use of "soft money" for a host of union activities for candidates, political parties, referendums and ideological causes.

And spend it the unions do. Political historian Theodore White called the AFL-CIO political effort in 1968 "unprecedented in American history." It included, for example, the registration of 4.6 million voters, the printing and distribution of 115 million pamphlets and leaflets, telephone banks in 638 localities, 72,225 house-to-house canvassers, and nearly 100,000 volunteers on election day.

Labor columnist Victor Riesel estimates that the cost of organized labor's unreported "in-kind" political activities in 1976 was over $100 million. Allowing for inflation and the dramatic increase in union political action, that figure could top $150 million in 1984.

In response, more and more union members are speaking out against the flagrant abuse of their First Amendment rights, looking to the nation's courts for help.

The U.S. Supreme Court has ruled that the use of compulsory union dues for political, ideological and other non-collective bargaining activities is unconstitutional, violating employees' First Amendment rights. But some courts have strayed badly in their interpretation of the legal precedents.

This fall, the National Right to Work Legal Defense Foundation will seek from the Supreme Court a strict definition of collective bargaining and a uniform remedy to protect the constitutional rights of American workers against the use of their compulsory dues for union political spending. **(Ellis/Fails v. Brotherhood of Railway, Airline and Steamship Clerks)**

The issue is clear, the abuse widespread. Rank and file workers, especially those who choose not to become union members, have little or no say as to which candidates and causes their money is used to support.

As a federal appeals court has stated, this wholesale violation of employees' First Amendment rights damages workers twice: They are forced to "contribute" to political candidates they oppose, and their ability to finance candidates they do support is thereby severely diminished.

Nearly 200 years ago, Thomas Jefferson wrote: "To compel a man to furnish contributions of money for the propagation of opinions which he disbelieves, is sinful and tyrannical."

Unhappily, such tyranny prevails in America today in the form of union political spending financed by compulsory union dues. This tyranny can only be eliminated by the combined action of an informed press, an aroused citizenry and a responsible judiciary.

If you would like further information about this fundamental abuse of the First Amendment, please write us for a copy of our pamphlet, "The First Amendment vs. Union Political Spending: A 26-Year Legal Battle for Employees' Political Freedom", and more information about the landmark case, **Ellis/Fails v. BRAC.** Or call Joanna Boyce at 800-336-3600.

National Right to Work Legal Defense Foundation
Dept. TR
8001 Braddock Road
Springfield, VA 22160

Although most computer specialists are building shallow but practical systems, a courageous few are trying to give computers common sense.

Continued from page 70

dumb it's almost impossible to tell them how to do things right.

Isn't it odd, when you think about it, how even the earliest AI programs excelled at "advanced" subjects yet had no common sense? A 1961 program written by James Slagle, then an M.I.T. graduate student and now a researcher at the U.S. Naval Research Laboratory, could solve calculus problems at the level of college students; it even got an A on an M.I.T. exam. But it was not till around 1970 that the staff at M.I.T.'s AI Lab managed to construct a robot program that could see and move well enough to handle ordinary things like children's building blocks and do things like stack them up, take them down, rearrange them, and put them in boxes.

Why could we make programs do grownup things before we could make them do childish things? The answer is a somewhat unexpected paradox: much "expert" adult thinking is basically much simpler than what happens in a child's ordinary play. It can be harder to be a novice than to be an expert. This is because (sometimes, anyway) the things an expert needs to know can be quite simple, however difficult they may be to discover in the first place. Thus, Galileo had to be smart indeed to see the need for calculus, even though he didn't manage to invent it. Yet any good student can learn it today.

Surprisingly, when Slagle's program was finished, it needed only about a hundred "facts" to solve its college-level calculus problems. Most were simple rules about algebra. Other rules helped the progam guess which of two problems was likely to be easier, so it could make good judgments about what to do next. Without that kind of knowledge, such programs would only thrash about; with it they seem much more purposeful. Why do human students take so long to learn such rules? We do not know. Today we know a lot about making such programs, but we still don't know much about making ones with common sense.

Consider the kinds of things little children can do. The 1970 robot program that made a computer do simple things inside a "children's world of building blocks" needed ways to combine different kinds of knowledge about shapes and colors, space and time, words and syntax. In all, the robot program needed several thousand knowledge fragments where Slagle needed only about a hundred, although the former just "played with toys" while the latter could solve college-level problems. An expert can sometimes get by with deep but narrow bodies of knowledge—but common sense is, technically, a lot more complicated.

While most ordinary computer programs do only the things they're programmed for, some AI programs are more flexible. When anything goes wrong, they can back up to some previous decision and try something else. But even that is much too crude a base for intelligence. To make the programs really smart, we'll have to make them more reflective. When things go wrong, a person tries to understand what's going wrong instead of just attempting something else. We look for causal explanations or excuses, and when we find them, we add them to our networks of belief and understanding. We do intelligent learning. Some day programs, too, could do such things—but first we'd need a lot more research to find out how.

Unconscious Fears

I'll bet that when we try to make machines more sensible, we'll find that learning what is wrong turns out to be as important as learning what's correct. To succeed, it helps to know the likely ways to fail. Freud talked about censors in our minds that keep us from forbidden acts or thoughts. Though he believed that censors regulate our social activity, I think we also use such censors for ordinary problem solving—to know what not to do. Perhaps we learn a new censor each time anything goes wrong by constructing a process to recognize similar circumstances in some "subconscious memory." This idea is not popular in contemporary psychology, perhaps because censors only suppress behavior, so their activity is invisible on the surface. When a person makes a good decision, we tend to ask what "line of thought" lies behind it. But we don't so often ask what thousand prohibitions might have warded off a thousand bad alternatives.

If censors work inside our minds to keep us from mistakes and absurdities, why can't we feel that happening? Because, I suppose, so many thousands work at once that if you had to think about them, you'd never get much done. They have to ward off bad ideas before you "get" those bad ideas. Perhaps this is one reason why so much of human thought is "unconscious." Each idea that we have time to contemplate must be a product of many events that happen deeper and earlier in the mind. Each conscious thought must be the end of processes in which it must compete with other proto-thoughts, perhaps by pleading little briefs in little courts. But all that we sense of those processes are just the final sentences.

And how, indeed, could it be otherwise? There's no way any part of the mind could know everything that

Should we build machines that might somehow be "better" than ourselves?

happens in the rest of the mind. Our conscious minds must be like high executives who can't be burdened with the small details. There's only time for summaries from other smaller parts of the mind that know much more about much less; they are the ones that do the real work. Is it possible to program a computer to be self-conscious? People usually expect the answer to be "no." What if we answered that machines are capable, in principle, of even more and better consciousness than people have?

I think this could be done by providing machines with ways to examine their own mechanisms while they are working. In principle, at least, this seems possible; we already have some simple AI programs that can understand a little about how some simpler programs work. The trouble is, we still know far too little to make programs with enough common sense to understand even how today's simple AI problem-solving programs work. But once we learn to make machines that are smart enough to understand such things, I see no special problem in giving them the "self-insight" they would need to understand, change, and improve themselves.

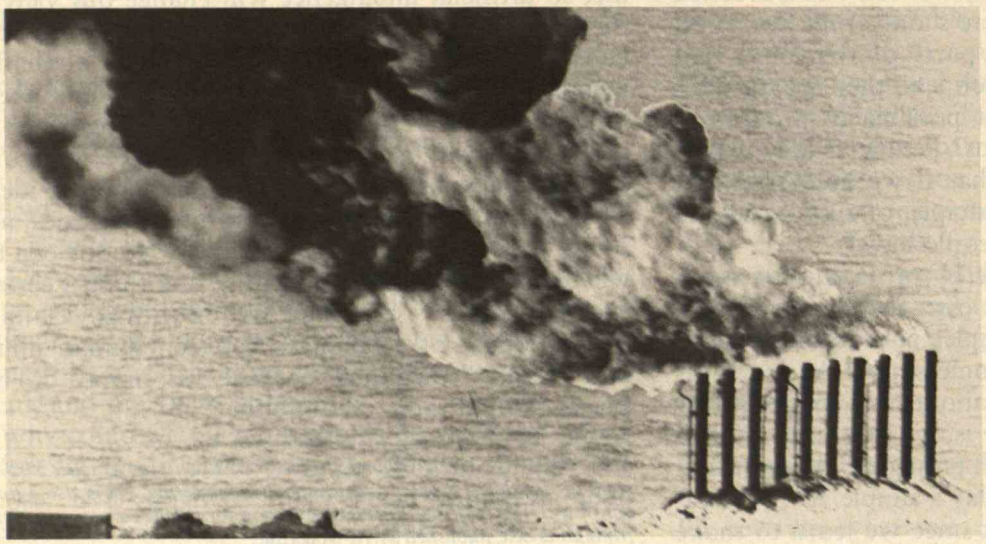
Of course, this might not be so wise. But what if it turns out that the only way to make computers much smarter is to make them more self-conscious? For example, it might turn out to be too risky to assign a robot to undertake some important, long-range task without some "insight" about its own ability. If we don't want it to start projects it can't finish, we'd better let it know what it can do. If we want it versatile enough to solve new kinds of problems, it may need to be able to understand how it already solves easier problems. In other words, it may turn out that any really robust problem solver will have to understand itself enough to change itself. Then, if that goes on long enough, those artificial creatures may reach for richer mental lives than people have. Our own evolution must have constrained the wiring of our brains in many ways. But we have more options with machines since we can wire them in any way we wish.

It will be a long time before we learn enough about common-sense reasoning to make machines as smart as people. Today, we already know quite a lot about making useful, specialized, "expert" systems. But we still don't know how to make them able to improve themselves in interesting ways. When we answer such questions, then we'll have to face an even stranger question. Should we build machines that might somehow be "better" than ourselves? I'm sure our future generations won't build machines that sophisticated unless they find good reasons to.

Just as the theory of evolution changed our view of life, so artificial intelligence will change our view of the mind. As we find more ways to make machines behave more sensibly, we'll also learn more about our mental processes and find new ways to think about "thinking," "feeling," and "understanding," not as single, magical faculties but as complex yet comprehensible webs of ways to represent and use ideas. Those ideas, in turn, will lead to new machines, and those, in turn, will give us new ideas. No one can tell where all this will lead and only one thing's certain even now: there's something wrong with any claim to know, today, of differences between human minds and possible machines, because we simply do not know enough today about either.

MARVIN MINSKY is Donner Professor of Science in M.I.T.'s Department of Computer Science and Electrical Engineering. He is also a founder of M.I.T.'s Artificial Intelligence Laboratory. This essay was adapted from an article published in AI Magazine.

Flaring of natural gas represents a wasted opportunity for the OPEC world—one on which it will soon be capitalizing. The result will be a major shift of basic petro-chemical production away from the industrialized nations by 1990.



Petrochemicals: International Competition

The balance of power among producers of basic petrochemicals is shifting from the industrialized nations to the energy-rich developing countries, say John J. Gersic of the U.S. International Trade Commission and Theodore W. Schlie, director of the Office of Competitive Assessment in the U.S. Department of Commerce. U.S. makers of major mass-produced organics such as ethylene, methanol, and ammonia could find themselves in a serious economic crisis by the end of this decade.

These major petrochemicals are all produced most economically from natural gas. When used as a feedstock, natural gas costs $2.50 to $5 per 1,000 cubic feet in the United States, and it's available at comparable prices in Europe and Japan. But most of the natural gas that comes to the surface when the OPEC nations pump their prodigiously rich oil wells is simply flared—wasted—because there is no market for it in the Middle East. When it is sold, the price can be as low as 50 cents per 1,000 cubic feet.

Given the price differential and the fact that the cost of natural gas is at least 60 percent of the cost of making the major organics, the handwriting on the wall is easy to read. And having read it, the OPEC countries are busily building new basic petrochemical industries—yet another challenge to a technology in which the United States has tended to take its superiority for granted.

By 1990 the United States, Europe, and Japan—now producers of 90 percent and users of 85 percent of the world's petrochemicals—could import more ethylene, methanol, and ammonia than they export, Gersic told members of the American Chemical Society this fall. "Severe price competition" is likely by then, he warned—which would result in a $1.8 billion change in the U.S. balance of trade in chemicals and perhaps 31,000 jobs lost in the industry.

Gersic and Schlie agree on the key question: Can U.S. petrochemical makers move fast enough to develop alternative products—specialty petrochemicals for which OPEC will have neither the technology nor the manufacturing capacity by 1990? Schlie suggests producing plastics for structural applications—car frames, for example—or high-strength petrochemical-based fibers such as Kevlar. Gersic believes we also ought to investigate ways of producing new chemicals through biotechnology.

Already, Japan and some other traditional producers are seeking in just this way to revamp their petrochemical industries, reducing capacity and embracing new products. The United States must do the same—only sooner, warns Schlie.

—John Mattill □

Changing Doctors' Habits

Medical researchers have found that a little personal contact goes a long way toward persuading doctors to stop prescribing unnecessary drugs. In a three-year study conducted by researchers at Harvard Medical School (HMS), more than 400 doctors in four states were visited by pharmacists or sent brochures. Both had essentially the same message: that doctors should cut back on prescribing three particular drugs that could easily be replaced by less expensive or more effective medication. The HMS researchers discovered that physicians who received visits from the pharmacists prescribed fewer unnecessary drugs than those who received only printed brochures or nothing at all.

"We took human behavior into account," says Dr. Jerry Avorn, an assistant professor of social medicine and health policy at HMS. "People don't just make decisions by weighing the pros and cons. Their decisions are based on irrational factors, and one of those factors is that people receive information better when it's given face-to-face than when they read about it in the mail."

Avorn and Stephen Soumerai, an instructor in social medicine and health policy at HMS, conducted the $160,000 study with funding from the National Center for Health Services Research, a federal agency.

The drugs chosen as targets for this pilot program were propoxyphene, a painkiller;

PHOTOGRAPH: BECHTEL POWER CORP.

papaverine, a drug that dilates blood vessels; and cephalexin, an antibiotic commonly prescribed for urinary-tract infections. When propoxyphene was first introduced in the 1950s, it was heralded as a potent painkiller more effective than over-the-counter remedies but without the addictive qualities of morphine. According to Avorn, it became a best-selling medication and continues to be widely prescribed—even though recent studies show it is generally inferior or at best comparable to aspirin.

The researchers chose papaverine for much the same reason. When papaverine was introduced (along with other vasodilators) early this century, many physicians thought senile dementia was caused by inadequate blood flow to the brain. That explanation has since been discarded, and other studies have shown that vasodilators do not effectively dilate major blood vessels. Yet papaverine is still commonly prescribed for treatment of dementia.

Cephalexin was selected for a different reason. According to Avorn, its use reflects a major problem in drug treatment today: the tendency of pharmaceutical companies to heavily promote newer, more expensive antibiotics when less expensive alternatives would do just as well.

"Pharmaceutical companies spend an average of $5,000 per physician per year to acquaint practitioners with specific products and encourage their use," Avorn says in a report of his study published in the *New England Journal of Medicine*. The pharmaceutical companies promote their products by inundating physicians with colorful literature and free drug samples and organizing fancy educational symposia that physicians and the companies themselves can deduct as business expenses. "The more staid format of medical literature often fares poorly next to the effective marketing strategies" of these companies, Avorn says.

For their pilot study, the Harvard researchers selected a sample of 435 physicians who frequently prescribed the three targeted drugs, as determined from state Medicaid records. The physicians, who practiced medicine in Arkansas, New Hampshire, Vermont, and the District of Columbia, were divided into three groups: those who received one or two personal visits from faculty at local pharmaceutical schools; those who received only printed material; and those who received nothing at all. The researchers then compared the physicians' prescribing habits by studying the computerized Medicaid claims.

"We had to write a sophisticated computer program that could extract the doctor's name and profile from the millions of Medicaid drug claims submitted for reimbursement by pharmacists in each state," Avorn says. "Fifteen years ago, analyzing this huge database would have been extraordinarily expensive or downright impossible."

The researchers found that physicians who received personal visits prescribed 531 fewer pills than those who received only brochures, and 782 fewer pills than those who received nothing at all. The change in these physicians' prescribing habits not only improved the quality of care; it also saved money. The study, which took into account only the Medicaid portion of each doctor's practice, saved about $105 in drug costs per physician.

Avorn believes the educational outreach approach could be adapted for widespread use by health-care programs that cover medication costs, such as state Medicaid agencies, the Veterans Administration, and some private health maintenance organizations. A similar approach might also be used to improve other clinical decisions such as ordering diagnostic tests and hospitalizing patients, Avorn says.

"The financial incentive is one selling point for this type of program," Avorn says. "Organizations that cover medication costs might become interested in the program as a way of improving the quality of care and controlling costs at the same time."—*Alison Bass* □

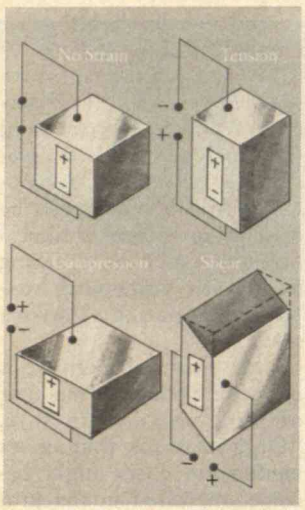
Piezoelectricity: An Old Idea With New Change

Piezoelectricity—electricity created by mechanical force—was discovered as a concept 100 years ago and developed as a technology almost 40 years ago. Yet only now is it attracting commercial interest as an efficient source of energy for small devices in computers, telephones, and medical equipment.

In 1880, the French physicists Pierre and Jacques Curie were the first to discover that by putting pressure on quartz, tourmaline, and other crystalline stones, they could generate an electric charge across opposite faces of the crystal. They called this phenomenon piezo, after the Greek word for pressure, and it has been naturally exploited for decades in quartz watches and radios. The first synthetic piezoelectric material was discovered by accident toward the end of World War II, when an M.I.T. graduate student found that barium titanate, a crystalline compound, became piezoelectric when it was polarized.

The U.S. Navy immediately began procuring piezoelectric materials for use in sonar buoys that monitored shipping lanes and helped detect enemy submarine activity. The piezoelectric principle can be used in both sending and receiving sonar messages. Piezo properties work in reverse, so an electric charge applied to a piezo ceramic stresses the material and produces a mechanical pulse to send through the water. After the pulse bounces off an object such as a submarine, the echo can be detected by a piezo receiver and translated into an electrical charge. The

ILLUSTRATION: JON MCINTOSH



Piezoelectric materials compress, stretch, or shear depending on where electrical contacts are placed and which way the current flows.

charge is then "read" by a sonar monitor.

Synthetic piezoelectricity evolved as a usable technology about the same time the technology for manufacturing semiconductor chips was being developed. But while the semiconductor industry began to flourish, with chips being used for both military and civilian applications, piezoelectricity remained, until recently, the sole purview of the navy.

The reasons for this are twofold. First, the demand for tiny electrical devices was not as great in the 1950s as it is today. Second, the early developers of piezoelectric materials patented them, stifling the chance for other entrepreneurs to enter the market and improve on the original designs. By contrast, the early semiconductor technologies and processes were widely available for modification and licensing.

With today's strides in computer, data-communication, and medical technology, piezoelectricity has attracted renewed interest. A company called Piezo Electric Products, founded by Eric and Henry Kolm, two of piezo's early pioneers in the 1940s, is producing fans for cooling computers. When an electric current is passed through a tiny sheet of polarized ceramic, the sheet flutters and blows air. According to John Terrell, vice-president for engineering at Piezo Electric Products, the fan is tiny enough to insert inside microcomputers. And unlike a standard rotary fan, it creates no heat of its own since it has no motor. It also uses about one-fifteenth the current a rotary fan uses, making it more economical. Although Terrell will venture no sales predictions, he says a number of manufacturers of computer hardware have shown some interest in the fan.

Other developers are interested in using layered sheets of polarized polyvinylidene flouride (PVF2) to make lightweight microphones for headsets used by telephone operators. The speaking voice would, in effect, produce an electrical signal strong enough to send across telephone lines. Although American Telephone and Telegraph has not publicly expressed interest in piezoelectricity, the French national Post Telephone and Telegraph Co. is hoping to revamp its telephone system using PVF2 plates in the mouthpiece.

Piezoelectricity may also be used in medicine in an unique way. Diabetics often develop lesions on the soles of their feet that make walking difficult. Physicians have been looking for a way to analyze the problem before it throws off a diabetic's walk and causes permanent muscle and joint damage. Now professors Norman McMillan and Peter Cavanaugh of Pennsylvania State University have created a piezoelectric ceramic "sock" that determines where the diabetic individual is applying force on the foot to avoid putting pressure on painful lesions. The mechanical force of walking produces an electric current, and the sock feeds this current into a computer, which provides a readout of exactly where force has been applied. With this information, doctors and biomedical engineers can better design shoes or inserts to prevent damage to muscles and joints.

In another development, studies have shown that sending a low electric current through bone can help knit fractures by inducing bone growth. However, the patient must somehow be plugged into a wall socket to get the proper intermittent current. A piezo walking cast would theoretically allow patients to create their own electrical energy while walking, and a piezo bone implant could create electrical energy each time an injured limb swings. In fact, experiments at the Universite Paul Sabatier in Toulouse, France, indicate that such a bone implant may work. Professor J.J. Ficat recently implanted a piece of piezoelectric material on one hind leg of a rabbit and a piece of nonpolarized material on the other leg. Bone growth occurred around the piezo implant.

Some piezo developers are also looking ahead to using piezo technology to generate electricity from steam and through windmills. Terrell, of Piezo Electric Products, says early experiments have shown that both ideas are technically feasible but not yet economically sound.—*Jon Zonderman* □

Laser Weapon Update

A Laser Weapon Fizzles" (*August/September, page 79*) reported that the Airborne Laser Lab (ALL), an attempt by the U.S. Air Force to put a laser weapon in an aircraft, was on its death bed. Now the ALL is up and about again, though whether it will ever get anywhere remains in question.

Shortly after the article appeared, the air force claimed that the ALL had "successfully defeated" five Sidewinder missiles at the China Lake, Calif., test range. "Although the flying laboratory is not a prototype weapon system," a spokesperson told reporters, "the completion of this program is a major milestone in the continuing air force program to further our understanding of the technical feasibility of laser weapons."

But that test, it now appears, may have proved as little as a previous one that had mainly provided spectacular film footage of an airplane going up in smoke. The target had been a slow-flying model airplane, and the laser had struck a fuel tank protected only by a cloth cover—hardly a realistic battlefield situation.

During the recent tests, carried out last May 31, Sidewinders were indeed destroyed. But did laser weapons destroy them? The Department of Defense (DOD) itself later admitted in a press release that a charge was exploded in each missile. Supposedly, the explosion occurred only after sensors indicated that the lasers had

DIAGRAM: PIEZO ELECTRIC PRODUCTS, INC.

Last May 31 the air force's Airborne Laser Lab (ALL), an experimental laser weapon, struck a Sidewinder missile. The missile blew up—with a little help from an explosive charge. Skeptics say the test proved nothing, but it may have impressed lawmakers. They restored funding to the moribund ALL program.

"defeated" the missile.

Why did the air force blow the Sidewinders up? "To provide a visual indication of a 'kill,'" according to the DOD. The ordinary procedure would be to allow the missiles to continue in flight after the test to see what the laser beams had accomplished. Skeptics argue that the tests were actually intended to provide photos to impress the media and Congress with the ALL program. Senator Malcolm Wallop (R-Wyo.), a strong laser-weapon advocate, was not impressed and continues to oppose the ALL, according to a staffer.

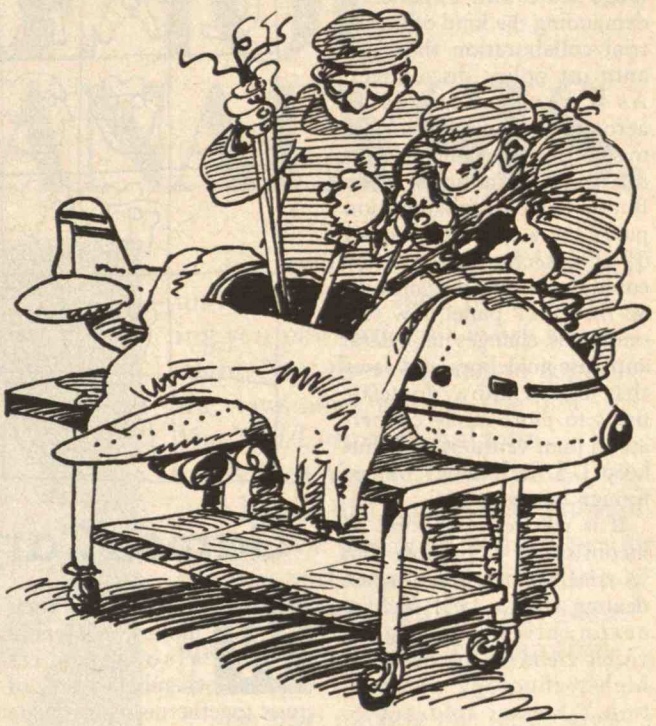
But other lawmakers apparently put more stock in the tests. Before hearing of them, the House Armed Services Committee had voted to delete all funds for the flying laser. However, later this summer a Senate-House committee salvaged the program, allocating $62.5 million of the $82.5 million requested by the Reagan administration.—*Carolyn Meinel* □

Time to Overhaul Aeronautics

In its love affair with space, the United States has neglected traditional aeronautical design, making too little effort to capitalize on major advances in microelectronics and metallurgy. As a result, the technology that determines whether the United States will maintain its leadership in civil and commercial aircraft is in "serious jeopardy," according to John E. Steiner, vice-president of Boeing Co.

In response to that gloomy forecast, the President's Office of Science and Technology Policy (OSTP) launched what Steiner now calls "the most comprehensive effort ever made by the government to understand just what makes U.S. aeronautics tick." The result is a report that calls for an aggressive research and development program in aeronautics.

The OSTP report highlights three areas—better aerodynamics, new materials, and advanced electronics for flight control—where research and development could pay off handsomely in the next 20 years. For instance, the development of low-temperature wind tunnels, in which aerodynamics can be studied with very small-scale models using tiny sensors and complex computer simulations, means that model tests could replace full-scale flights. This would lead to dramatic advances in aerodynamics: the ratio of lift to drag could be doubled by the 1990's. As a result, the takeoff weight of a future supersonic fighter could be reduced by 20 to 30 percent. Commercial aircraft might use 20 to 40 percent less fuel, which would reduce operating costs 10 to 20 percent.



Advances in materials science suggest that structural parts of aircraft can soon be built from new plastic resins and alloys of titanium and aluminum that are 30 percent stronger than those in use today. Since smaller amounts of these improved materials would be needed, the weight of an aircraft's structure could be reduced by 20 to 50 percent; that could mean a fuel savings of more than $2 billion over the lifetime of a commercial jet. New materials also hold the key to major advances in aircraft engines, allowing higher-temperature operations with thrust-to-weight ratios up at least 20 percent.

Rapid advances in microelectronics promise further weight reductions and more automation, according to the OSTP. A typical modern flight-control system that draws 250 watts of power, weighs 25 pounds, and costs $100,000 should be replaced by 1990 with one that uses 50 watts, weighs 6 pounds, and costs $30,000. Replacing today's mechanical, hydraulic, and pneumatic systems with electronics would reduce the total weight of a typical commercial jet by 10 percent with fuel savings as high as 20 percent, the report says.

Taken together, these new technological advances could increase the fuel efficiency of transport aircraft by 50 to 100 percent before the year 2000, cut manufacturing costs by 10 to 20 percent, and reduce maintenance costs by 20 to 40 percent. Research and development over the next 20 years could also pave the way for an acceptable supersonic transport.

To achieve these gains, a major R&D program is re-

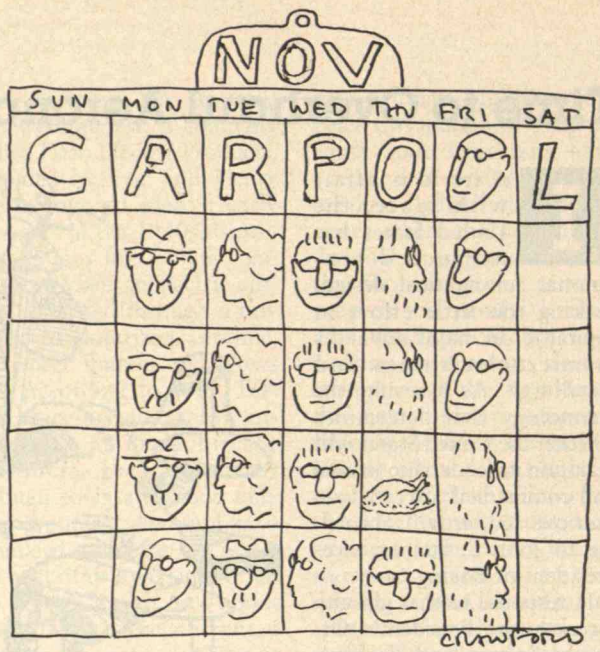
PHOTOGRAPH: U.S. AIR FORCE

ILLUSTRATION: JON McINTOSH

quired, says the OSTP report. Some of the needed work is large-scale and expensive, demanding the kind of industrial collaboration that U.S. antitrust policy discourages. As a result, domestic aeronautics companies tend to seek overseas collaborators unaffected by antitrust rules. But that kind of collaboration paves the way for the export of U.S. technology, which could then be used against us. So the OSTP panel now recommends changes in federal antitrust guidelines and laws that would allow domestic firms to more easily cooperate in joint ventures and thus keep U.S. technology out of foreign hands.

It is precisely this kind of inconsistency of purpose that worries Steiner. Even when dealing with a field such as aeronautics—"a highly visible arena for international high-technology competition," Steiner told a U.S. House committee last fall—the United States tends to "set the rules and let things turn out as they may." Other countries, Steiner says, emphasize results, not rules, and change the rules if necessary to reach their goals. An aeronautics R&D program such as the OSTP panel suggests requires commitment to a long-range plan, for which Steiner finds less precedent that he wishes in U.S. policymaking.

But George A. Keyworth, director of OSTP, has been reassuring. In a meeting with the Aero Club in Washington shortly after the report was released, Keyworth promised continued federal support of aeronautics research and technology. He said the report illustrates "a clear consensus, a shared understanding of basic objectives and responsibilities."—*John Mattill* □



Games Carpoolers Play

While it saves their money, a carpool also gives its members a time of quiet togetherness—a private island in the maelstrom of traffic. What happens when the occupants of that island are computer researchers? Answer: a mathematical formula for determining each day's driver that is claimed superior by all tests of fairness.

The simplest system, of course, is rotation: each driver takes his or her turn in sequence. Complications arise when John, who has to be out of town on his day to drive, trades with Bill, who then trades with Phyllis because his car is unexpectedly disabled. The resulting confusion proved anathema to computer experts Ronald Fagin and John H. Williams who work at IBM in San Jose.

So they spent their carpooling hours seeking a better way—"a scheduling algorithm that will always be tolerant of exceptional conditions"—and reported their results in the *IBM Journal of Research and Development*. They sought a method that allows a person to drive on a day when someone else is scheduled yet one that is easy to get "back in sync" later. And they did not want any unfairness in their method to discourage people from participating in the carpool.

Having rejected rotation, Fagin and Williams tried a "token" system: each rider who travels pays a token to that day's driver. The next day's driver is the carpooler who has fewest tokens. But this scheme fails the carpoolers' fairness test: it gives everyone an incentive to drive on days with all carpool members present.

Next, Fagin and Williams devised a system for carpool drivers to accumulate credits on different ledgers, one ledger for each possible combination of driver, riders, and absentees. If Phyllis drives and John is her only passenger, she has one credit on the Phyllis-John ledger; if she drives a full carpool she claims one credit on the Don-John-Phillip-Ron-Phyllis account. The next time the carpool contains only Phyllis and John, the ledger reveals that John should be the driver. That system is fair, conclude Fagin and Williams, but too complicated.

Finally, they came up with a solution: Take all the integers starting at 1 and going up to the number of members in the pool. For example, if the carpool has four members, take the integers 1, 2, 3, and 4. Find the smallest integer that can be divided by each of these—in this case 12. This represents the "cost" of a car trip to work and is divided among each day's riders. Thus, if three people are in the carpool, the cost for each is 4—12 divided by 3. The driver's cost is forgiven, and the riders' costs are credited to the account of the driver, who gains 8 credits. With four in the carpool the cost to each rider is 3 and the driver gains 9 credits.

Deciding the next day's driver simply requires determining the carpooler with the fewest credits among those who will be traveling. The system is both fair and manageable, say Fagin and Williams. And if a carpooler fails to drive when his or her point total is lowest, the deficit continues to accumulate fairly.

Furthermore, the system offers a way for carless members of the carpool to contribute cash rather than drive. The ride units of this scheme could be priced like any other commodity, so nondriving carpoolers could put up money instead of service. In fact, the Fagin-Williams carpool in which these explorations were conducted contained just such a nondriving

ILLUSTRATION: MICHAEL CRAWFORD

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member. His name was Don, and soon enough the ride units in the carpool's legal tender became known as "dodecadons."—*John Mattill* □

Killing Pests With Less Pesticide

In 1981 Nicaraguan farmers sprayed their cotton fields with pesticides an average of 27 times yet still lost a fifth of the crop to the boll weevil, according to Sean Swezey, a professor in the integrated-pest-control program at the Autonomous University of Nicaragua. In the end, the 1981 cotton crop brought in less money than it cost to produce, with pesticides representing 30 percent of that cost, says Swezey.

Even in developed countries, pesticides have limitations. Pests can become resistant to them, and "secondary pests," ordinarily controlled by other insects, can proliferate when the ecological balance is upset. But for developing countries, the biggest drawback in using pesticides is simply the cost to import them—especially considering the huge international debts owed by these countries. A country cannot repay its debt by selling "cash" crops that bring in less money than they cost to produce.

After the 1981 failure, Nicaragua's future in growing cotton on a large scale looked bleak, and the government was willing to take drastic action. The Ministry of Agriculture and Agrarian Reforms, to which Swezey is an advisor, endorsed a program of "integrated pest control"—a technique that employs natural ecological mechanisms as well as chemical pesticides to control insects.

The technique involved killing the boll weevils as they bred on cotton plants. During the harvest in late January and early February of 1982, farmers in the Leon region left islands of green cotton stubble standing, and technicians placed a sex pheromone, or scent, as bait in each island. Since boll weevils prefer to breed in cotton if it is available, most were attracted to those scented islands. Technicians then sprayed relatively small amounts of pesticide on the individual islands each day to kill any weevils that had arrived.

After the first rains in May but before the usual planting time, farmers put new cotton plants with a pheromone bait next to the islands of green stubble to create stronger weevil traps. By June these were attracting mating weevils, and farmers could apply pesticides. Daily spraying continued for about two months.

By the time the regular cotton crop was mature enough to begin attracting weevils, there were simply too few left to cause serious damage. In an area of about 30,000 acres, the program of integrated pest management saved $2.14 million, according to a follow-up study conducted by Swezey and Rainer Daxl of the German Society for Technical Cooperation.

There had been a university-sponsored integrated-pest-control program in Leon in the mid-sixties, Swezey says, but it was ineffective because some farmers failed to participate. Their fields became breeding areas for the pest, which then invaded neighboring fields. Regional planning was clearly necessary—only with government help could the weevil-suppression project achieve the required 100 percent participation among farmers.

The 1983 program includes the entire cotton-growing area of Leon—about 100,000 acres—and Swezey's preliminary results show that use of pesticides has dropped 60 percent. Pesticides now account for only 10 to 15 percent—rather than 30 percent—of total production costs. This success has prompted the government to consider integrated-pest-control programs for other crops.—*Peter Downs* □

High-Tech Planetariums

When electric lights and pollution filled city skies in the early twentieth century, they did not render obsolete the ancient preoccupation with stargazing. In the thirties, the first planetariums—such as the Adler in Chicago, the Griffith in Los Angeles, and the Hayden Planetariums in New York and in Boston—were built to bring the dark skies indoors. The Spitz and Zeiss projectors of those days were crude—not much better than curved sheets of galvanized iron drilled with holes and lit from within by the then-novel electric lamp. Narrators lectured audiences about the heavens along with the star shows. As the Danish astronomer S. Elis Stromgen said early in this century, a planetarium should be a "schoolroom beneath the dome of the sky."

In recent years technology has not only changed the sights and sounds of the planetarium experience; it has also provided forms of entertainment unimagined by earlier audiences. These new audiovisual effects are threatening to erode the traditional educational role of planetariums, and the demand for implementing the technology is causing severe financial strains.

Change was unavoidable: audiences have grown more demanding. They have seen the moon walk and the rings of Saturn on their television screens. They have become familiar with the marvels of science-fiction cinematography. To keep up, planetarium managements have had to brighten their domes with sophisticated technology. Today, solar systems are projected from every imaginable angle, and stars and planets are shown being born and exploding. Audiences are nearly engulfed by black holes, sit comfortably under meteor showers, and enjoy accurate sceneries of journeys through space.

For example, "The Mys-

ILLUSTRATION: JON MCINTOSH

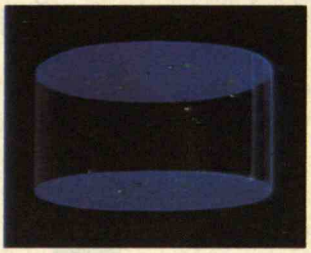
terious Heart of the Milky Way," a show produced at Griffith Observatory in Los Angeles, first recounts changing perceptions of the Milky Way throughout history. Later, the audience experiences the sensation of taking off from the ground and zooming through the Milky Way. Mysteries of star clusters and nebulae are unraveled as dome-sized images of clouds of dust and gasses are projected overhead.

Griffith Observatory claims to be the last bastion of shows with live narrators, and director Ed Krupp intends to keep it that way. Yet he expects to spend close to $3 million in the next two years on new technology. The new Digistar computerized projection system will store information ranging from names and locations of stars and planets to all types of moving images, and these will be projected throughout the dome by a fisheye lens.

Established planetariums may also feel pressure to adopt new audiovisual technology because of competition from a growing chain of nearly a dozen "hugedome" theatres run by Omni Corporation. These are designed to be a cross between a cinema and a planetarium. The seats are set out theatre-style rather than in the concentric circles traditionally used by planetariums. The dome is not directly overhead but rather is tilted at a 30-degree angle to maximize the viewing area and minimize the strain on the audience's necks.

The latest Omni theatre recently opened at the Fort Worth Museum of Science and History. It premiered *Hail Columbia!*—a film portraying the drama of the space shuttle from the planning stage to its re-entry after its second voyage. The

Marvels of high-tech planetariums (clockwise): the great nebula in Orion, replicating molecules at the beginning of life on earth, the cluster of two dozen galaxies to which ours belongs, and a bank of computers set against the Zeiss VI star projector.



theatre, which cost $8.5 million, is equipped with an Omnimax projector that runs film nearly ten times wider than the standard 35 millimeter at a rate of six feet per second. A computer system coordinates close to 100 slides, lighting, and special-effects projectors, as well as a six-channel sound system playing on 88 speakers.

Most planetarium administrators think the Omni theatres provide a good deal more entertainment than education. However, more and more entertainment has also found its way into the programs of planetariums—no longer are their wonders limited to celestial bodies.

In one educational program in New York's Hayden Planetarium, for example, a live performer uses the dome as backdrop while he travels through galaxies in search of "magic fruits." This performance, called "Slim Goodbody's Galactic Health Adventure," turns out to be a lesson in good nutrition rather than astronomy. A few years ago, the Hayden Planetarium in Boston featured a show based on "Last Question," a short story by Isaac Asimov, that included scenes such as a Great Galactic Council meeting and a tour of the supercomputer of the future, called Multivac.

"A planetarium is judged by the special effects and the sophistication of its computer systems," says William Gutsch, chairman of New York's Hayden Planetarium. Gutsch and his staff built custom devices to bolster the planetarium's two Eagle computers, which command 40 projectors.

New audiovisual technology is also the key to the after-hours light shows set to popular music that are fast becoming bread and butter for many planetariums. Krupp, for one, feels justified in making Griffith Observatory the home of such multimedia shows as Laserium. "No doubt it is in conflict with the idea of public education—it is pure entertainment. But the financial gains offset the planetarium's operating expenditures for our educational programs."

Educating the public was never a lucrative business, and today's demands only make matters worse. Big-city planetariums have the advantages of relatively large populations, hefty budgets, and access to new technology. However, the more than 1,000 smaller planetariums throughout the country—most run by school systems, colleges, or local parks and recreation departments—are not so fortunate.

Many have begun to close down in the last five years. According to Jeanne Bishop, president of the International Planetarium Society: "The planetarium is a vehicle for transmitting to the general public the state of the art of science and technology. If this trend continues, a vital link will be lost between the public and scientific research."—*Elizabeth Fullon Motzkin* □

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Relational Data Base

IBM

To: Dick
From: Bill
Subject: IBM Technology

I've been reviewing some of our past and present technological achievements, and it occurred to me that the scientific, engineering, and academic communities might like to know more about them. Will you select a topic from the following list? Thanks.

Vacuum tube digital multiplier
IBM 603/604 calculators
Selective Sequence Electronic Calculator (SSEC)
Tape drive vacuum column
Naval Ordnance Research Calculator (NORC)
Input/output channel
IBM 608 transistor calculator
FORTRAN
RAMAC and disks
First automated transistor production
Chain and train printers
Input/Output Control System (IOCS)
STRETCH computer
"Selectric" typewriter
SABRE airline reservation system
Removable disk pack
Virtual machine concept
Hypertape

System/360 compatible family
Operating System/360
Solid Logic Technology
System/360 Model 67/Time-Sharing System
One-transistor memory cell
Cache memory
Relational data base
First all-monolithic main memory
Thin-film recording head
Floppy disk
Tape group code recording
Systems Network Architecture
Federal cryptographic standard
Laser/electrophotographic printer
First 64K-bit chip mass production
First E-beam direct-write chip production
Thermal Conduction Module
288K-bit memory chip
Robotic control language

Bill -
It's a tough choice but I'd go with relational data base. It's a software development that's making a big impact.
Dick

PARTS

PARTNO	PNAME
P107	BOLT
P113	NUT
P125	SCREW
P132	GEAR

SUPPLIERS

SUPPNO	SNAME
S51	ABC Co.
S57	XYZ Co.
S63	LMN Co.

PRICES

PART#	SUPP#	PRICE
P107	S51	0.59
P107	S57	0.65
P113	S51	0.25
P113	S63	0.21
P125	S63	0.15
P132	S57	5.25
P132	S63	7.50

Figure 1. *Relational data base consisting of three tables.*

WHICH SUPPLIERS HAVE PARTS FOR LESS THAN $0.50?

SQL QUERY

USER INPUT:

```
SELECT PART#, PRICE, SNAME
FROM   PRICES, SUPPLIERS
WHERE  SUPP# = SUPPNO
       AND PRICE < 0.50
```

QBE QUERY

USER INPUT: DRAW PARTS, SUPPLIERS, SKELETON
COMPUTER-GENERATED TABLES AND USER INPUT:

SUPPLIERS	SUPPNO	SNAME
	_Sn	_Na

PRICES	PART#	SUPP#	PRICE
	_Pt	_Sn	_Pr <0.50

P.	_Pt	_Pr	_Na	

RESULTS

PART#	PRICE	SNAME
P113	0.25	ABC Co.
P113	0.21	LMN Co.
P125	0.15	LMN Co.

Figure 2. *An example of using IBM's very-high-level data base languages, SQL and QBE, to satisfy a request involving two tables from Figure 1. The SQL commands are expressed in a standardized block format; an example of the most common form for extracting data is:*

SELECT	some data (column names)
FROM	some file (table names)
WHERE	certain conditions, if any, are to be met (rows)

QBE is initiated simply by typing the table name on the display screen, and the screen returns a skeleton table with column names in it. In this example, the user builds a new table in the blank skeleton by typing "example elements" (e.g., _Pt) under existing tables and in the blank skeleton. The example elements are formed by typing an underline followed by any mnemonic the user desires. Note that "P." simply means to present the results.

With business information growing at the rate of two file drawers per office worker per year, and with increasing amounts of it stored in electronic data bases, new techniques are required to allow easy, yet controlled, access by workers who lack computer expertise.

Starting in 1970, IBM researchers formulated, implemented, and tested prototype relational data base systems. This new approach in data base processing virtually eliminates the need for computer experience among users.

The relational model opened the way to more flexible, easy-to-use data base systems. The two relational data base management systems marketed by IBM for intermediate and large computer systems—Structured Query Language/Data System, introduced in 1981, and IBM DATABASE 2, introduced in 1983—allow users to update, retrieve, insert, delete, and otherwise manipulate data merely by specifying *what* they want to do, without having to tell the computer *how* to do it.

These relational systems are especially "friendly" because of the familiar, easy-to-interpret manner in which users see the data—as two-dimensional, rectangular tables ("relations"), with all information arranged in columns and rows.

IBM developed two very-high-level languages, Structured Query Language (SQL) and Query-By-Example (QBE), to access the relational data bases. Both are easy to learn, easy to apply, and immensely powerful. The innovative concept of QBE, which had a significant influence on display-screen interfaces, uses a two-dimensional programming approach. All queries are made directly onto a blank "skeleton" table appearing on a display screen. The user extracts data by a fill-in-the-blanks mode. SQL is a linear language that comes very close to "speaking English." It may be used both by ad hoc users at terminals and by programmers to embed SQL

statements in application programs.

The non-navigational nature of the relational data base model endows QBE and SQL with extreme flexibility. Since there are no predefined information pathways to negotiate, the user is free to make all manner of ad hoc queries—an essential feature for applications where information needs change rapidly.

One of the most important IBM innovations in relational data base technology was a compiler approach to execute SQL statements. Replacing an interpretive approach, this compilation technique reduces the overhead cost of implementing the SQL language by using a precompiler to generate a tailored data access routine before execution time. The access routine, because it is tailored to one specific program, and is reusable, runs much more efficiently than a generalized interpreter.

In addition, the compilation technique uses a very sophisticated optimizer, which chooses economical access paths to the data. The compiler approach allows data base query in a high-level, easy-to-use language, yet also provides efficient program execution.

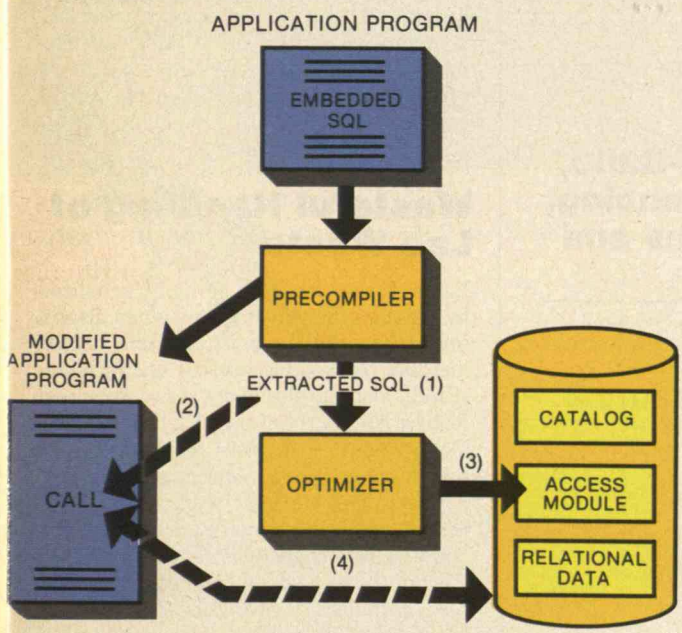

Figure 3. *The compiler approach is the key to IBM's efficient execution of SQL (very-high-level relational data base language) statements. This diagram illustrates the execution of application programs with embedded SQL statements. Programs are first processed by a precompiler, which extracts SQL statements from the application program (1). The precompiler also replaces the SQL statement in the host program with a CALL to the access routine (2). By very sophisticated analysis of available paths to the data, the optimizer chooses an economical path for the specific SQL statement, which is implemented as an access module (3). When the programs are executed, all the access modules for that program are loaded to provide targets for the modified CALLS (4).*

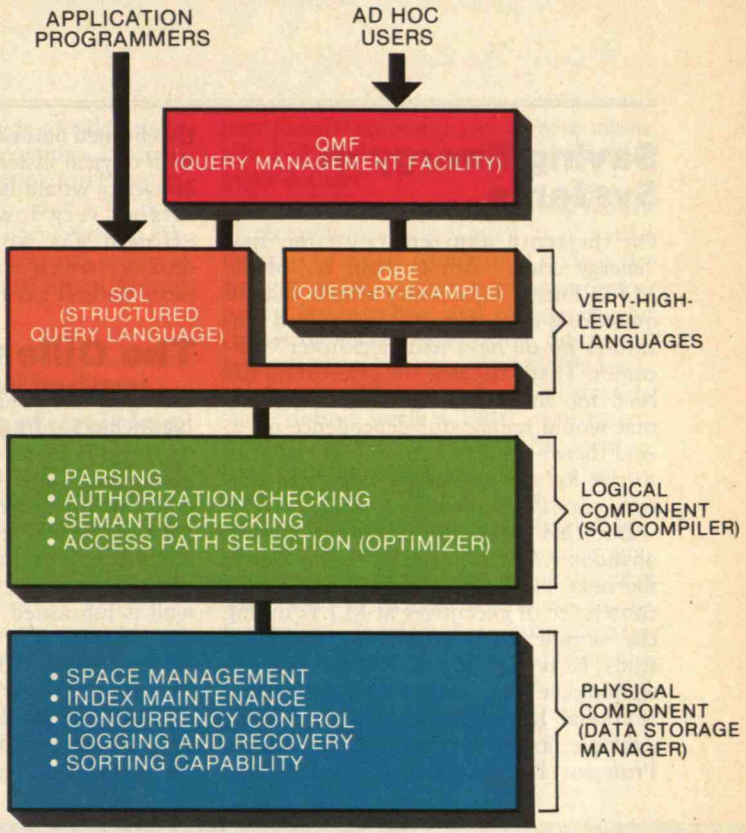

Figure 4. *This generalized architecture is the basis for IBM's relational data base products. It enables different types of users to access data easily, and yet is designed to handle complex programming tasks efficiently while providing the full function of a data base management system.*

Many scientists and programmers throughout IBM contributed to the development of relational data base technology, and researchers continue to explore future applications for the office environment and network users. These contributions are only part of IBM's continuing commitment to research, development, and engineering.

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Saving Energy in Systems

On the tenth anniversary of the first "energy crisis," Ben C. Ball, Jr., of the M.I.T. Energy Laboratory admits that all our efforts to save energy and to find substitutes for oil have had "lackluster" outcomes. That's because the price of oil has been too low to justify the investments that would reduce our dependence on it. And there's no reason to expect the price to rise for the rest of the twentieth century, says Professor Ball.

But this does not mean we should abandon research in energy technology in the next 15 years, Professor Ball told a conference of executives at M.I.T. during the summer. The promising areas for study, he said, are those in which familiar technologies are combined into unconventional higher-efficiency systems. For example, for an area such as Oklahoma, Professor Ball would explore a turbine that burned natural gas to make electricity with oxygen instead of air. The turbine's efficiency would be very high and its pollutants very low. And the turbine's effluent gas would be pure carbon dioxide, which would be used to force more natural gas from the earth. □

The Oilless Piston

One stumbling block to higher-efficiency, high-temperature engines may be removed by David P. Hoult's concept for an oil-free piston lubricated by gases in the engine combustion chamber. In conventional engines, the seal between the cylinder wall and piston is established by a piston ring, and the contact between that ring and the wall is lubricated by oil from the crankcase. Hoult's idea is that gas would be a better lubricant than oil, mostly because its viscosity is low and its effectiveness as a lubricant unaffected by temperature. A redesigned piston ring would fit the inevitable irregularities in the cylinder wall by twisting, not by springing, and in the process it would draw combustion gases into the interface to lubricate it.

Five years of work in M.I.T.'s Sloan Automotive Laboratory may be needed to prove the concept. Hoult thinks his oil-free piston may cut engine friction by a factor of 100 while permitting the high temperatures and efficiencies made possible by new high temperature ceramics. □

Cryogenic Power

Early next spring, M.I.T. will temporarily abandon the New England electric grid, relying instead for as long as a month for its power on a 10-megawatt superconducting generator now nearing completion by the Departments of Electrical and Mechanical Engineering. Generators produce electricity by a magnetic field from a spinning rotor. If the rotor is cooled to superconducting temperature (at which conductors offer essentially no resistance to the flow of electricity), the magnetic field it produces—and hence the amount of electricity generated—is greatly increased. Professor Joseph L. Smith, Jr., hopes next spring's test of the M.I.T. cryogenic generator, being built with Department of Energy funding, will help prove the reliability and efficiency of the cryogenic concept. □

Wasteful Handling of Lab Waste

Laboratories are now severely penalized by the rules they must follow when disposing of hazardous waste, and relief could increase the productivity of chemical research and development, says Professor Robert A. Alberty of the M.I.T. Chemistry Department. Professor Alberty's argument, made to the American Chemical Society's fall meeting as a result of his leadership of a National Research Council study of hazardous wastes, goes like this: Chemicals, biologicals, and other hazardous substances discarded by U.S. research laboratories represent less than 1 percent of all hazardous waste generated in the United States. But laboratories have to meet the same disposal requirements as industrial plants that handle chemicals in bulk—"an unnecessarily large reporting and record-keeping burden," Professor Alberty told the ACS. He and his NRC

colleagues have suggested regulations for managing laboratory chemicals that are much simplified but pose "no hazard to health or threat to the environment," Professor Alberty said. □

Swaying on the Railroad

How to conquer the side-to-side motion of railroad cars traveling at high speed—damaging to the cars' contents and to the track on which they ride?

Professor J. Karl Hedrick of M.I.T. has an answer: an active pneumatic system that senses lateral motion and instantly exerts a force to counteract it. The energy would come from the air brake system, and an accelerometer and logic unit measure the sideways movement and calculate the amount of air pressure that must be pumped into an airspring to offset it.

Professor Hedrick describes the system as "simple in concept but complicated in practice," because the side-to-side oscillations occur as fast as three times a second, and up to 3,000 pounds of force may be needed to control them. But a working model of the device has been tested in Professor Hedrick's laboratory, and he is testing a full-scale pilot model on an Amtrak car this summer. □

A Ten-Year Window of New Opportunities

If the recession that now grips the U.S. seems unusually tenacious, there's a reason, says Alan K. Graham, research director of the System Dynamics National Model Project in the Sloan School of Management.

The trouble is that we are in the trough of a business cycle and also at the bottom of a Kondratieff "long wave"—a 50-year cycle of overexpansion and technological change. The capital plant based on old technology is no longer fully utilized, but new technology is not yet ready to create jobs and profits—and may not be for another decade.

But the cloud has a silver lining: the era of technological innovation that marks the start of a new Kondratieff cycle is beginning, and it's a moment of great opportunity for investors and managers who choose the technologies of the future and invest in them now. Dr. Graham's advice: combine a conservative financial strategy (low debts) with a bold investment strategy, backing new ideas that seem to have the best chance for success when recovery begins.

"The corporate strategies adopted during the transition usually determine who survives to reap the benefits of the next 'long wave'," Dr. Graham writes in the *Journal of Business Forecasting*. Large debts are a special hazard during the long-wave transition, Dr. Graham writes, because "low profits squeeze cash flow and higher risks make banks less willing to lend." □

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